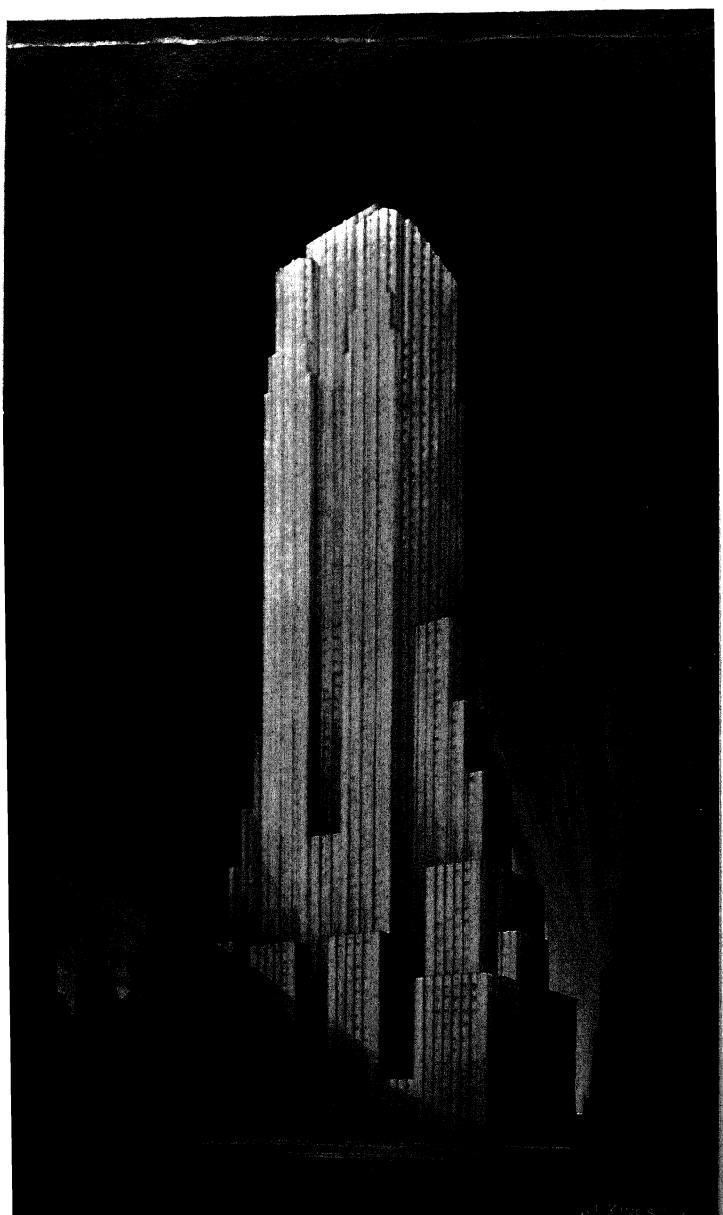


THE SKYSCRAPER
A Study



THE SKYSCRAPER

A STUDY IN THE ECONOMIC HEIGHT OF
MODERN OFFICE BUILDINGS

BY

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PUBLISHED BY

AMERICAN INSTITUTE OF STEEL
CONSTRUCTION, INC.

NEW YORK

CLEVELAND

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PRINTED IN U. S. A.

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*Heated
Controversy*

Few public questions are now being debated with more heat and more persistence. At the one extreme we have a group of critics, chiefly city planners of the more doctrinaire type, who are bitter and extravagant in their criticism of the skyscraper, who find in it the source of most of the evils in our city life and who advocate a definite restriction of building height to a maximum of eight or ten stories. At the other extreme is a school of protagonists who are enthusiastic and even lyrical in their praise of the skyscraper, who see in it both a necessary result of American conditions and a characteristic product of American genius, and who protest against any attempt to restrict or regulate its development. Ranging between these two extremes are individual thinkers who are willing to see both sides of the question, who appraise pros and cons on the basis of their individual experience or such facts as happen to be available to them, and who favor moderate programs of restriction or regulation based on their individual appraisals of merits and defects. As usual, however, it is the extremists who are most vocal and, in the face of their vague generalities and conflicting claims, the average citizen stands confused and confounded.

*An Historic
Controversy on a
Changing
Battlefront*

It will be enlightening to recall at the start that this public controversy over the skyscraper is by no means a new phenomenon; with more or less vehemence it has raged almost continually since the completion of the Tacoma Building in the city of Chicago about forty years ago ushered in the era of the skeleton steel frame building which is the true skyscraper. But an examination of the literature of the subject reveals an interesting story of how the battle front has shifted from time to time. In the early days, the attack was directed chiefly against the strange and unsightly character of these tradition-breaking "monstrosities" which dared to raise their heads to the dizzy height of 12 or 16 stories, against the way in which they "disfigured" the streets and against the possibilities of catastrophe involved in "the collapsing of one of these monster structures on a crowded street". In these attacks one recognizes, in part at least, the eternal

prejudice against "the new", the same prejudice which a little over a century ago led the English farmer to fight the introduction of the iron plow with all sorts of dire, fantastic prophecies and less than a century ago caused the doctors of a leading German city to prepare a weighty professional protest against the proposal to bring the railroad to their city on the ground of the danger to the health not only of those who dared to ride on the new-fangled device but also of those unfortunate citizens who could hardly escape injury to health from observing the trains as they raced through the countryside at the fantastic speed of 20 miles an hour. Later on in the attack on the tall building, as the civic consciousness became more sensitive to the slum problem, the critics increasingly emphasized the shutting off of light and air and the consequent unfavorable effect upon public health. In the last few years, with traffic conditions becoming almost intolerable in our leading cities, the skyscraper has proved a plausible scapegoat for this particular evil, and the "congestion" argument has consequently become the chief stock-in-trade of the conscientious objectors to tall buildings *per se*.

II

THE ECONOMIC ARGUMENT

The Private Owner's Viewpoint

DEMONSTRATION OF TRUE ECONOMIC HEIGHT

But while in the public mind today the strongest count in the indictment of the skyscraper is probably its alleged influence in increasing traffic and population congestion, there is another argument which demands prior consideration for reasons to be discussed later. This is the contention that the tall building is an economic fallacy,—that even from the private owner's point of view it does not "pay" and therefore should not be permitted. Now the solicitude of the critic for the poor building owner who foolishly insists on putting his money into unprofitable investments is somewhat amusing and hardly consistent with the claim that the latter is a robber of values that rightfully belongs to others, that he who is allowed to build a tall building is given an economic advantage which should be compensated for by heavier taxation, etc. However, if we are willing to overlook such patent inconsistencies, we will recognize in this "economic fallacy" argument an ingenious flank attack upon the position of the skyscraper enthusiast.

The "Economic Fallacy" Argument

Indeed, if this one point could be proved, the whole battle against the skyscraper would be won. Obviously, if it can be conclusively demonstrated that tall buildings as a class are unprofitable or less profitable than low buildings, investors will cease to erect such structures and legislators will not hesitate to discourage them. If the tall building *per se* involves

the sacrifice of private rights, the Courts will be apt to interpret the police power for zoning purposes much more liberally than otherwise. Arguments based on "light and air" protection, "fire hazard" or "traffic congestion" will be largely works of supererogation. On the other hand, if the tall building is found to be the most economical development of the central business sites of our leading cities, private owners will strenuously oppose any drastic confiscation of their property values and public opinion, the Legislatures and the Courts will back them up, except to the extent that a sound and reasonable exercise of the police power may require regulation in the obvious interest of public safety, health and morals. In other words, economic consideration will be the determining factor in this as in other fields of human progress. Society is willing to submit to reasonable regulation to reduce as much as possible the wastes and pains of progress; it is unwilling to see progress in a given direction blocked altogether.

Believing, therefore, in the fundamental importance of the economic factor, the writers determined to examine, first of all, the claim that even from the selfish standpoint of private profits, the tall building is not an economic unit. A cursory examination of the literature of the subject revealing little but conflicting general claims and meagre factual data, it soon became apparent that a detailed first-hand investigation of the facts would be necessary if a scientific conclusion were to be reached.

True, it did seem apparent that logic was on the side of the skyscraper protagonists. In the first place, tall buildings have existed for some forty years, are numerous today in all our leading cities and are being built in increasing numbers. Some of these may doubtless be explained by mistaken judgment or by exaggerated notions of advertising and prestige values, but is it reasonable to believe that builders and bankers and investors would be guilty of such persistent and widespread folly as the skyscraper critic's thesis, if true, would require?

In the second place, it would seem obvious that when land values reach a figure of \$50 or \$100 or \$200 a square foot, intensive development of this land would be necessary in order to support the heavy "carrying charges" of interest and taxes. Ten stories, it seems apparent, should carry these charges more easily than five, and twenty or thirty stories more easily than ten. Of course, even the layman recognizes that higher costs of construction and certain wastages of rentable area are incurred as height increases but, at first sight at least, it would appear unlikely that these would counterbalance the other factor until a considerable height were reached.

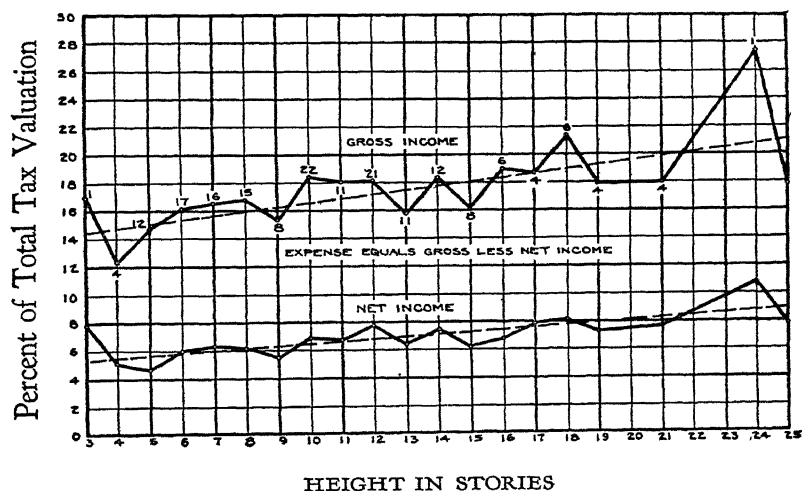
*Evidence from
Operating
Results
of Existing
Buildings*

Finally, we have as further evidence the results of a study of the operating experience of a large number of office buildings, made by Earle Shultz for the National Association of Building Owners and Managers. (1) Mr. Shultz, through the Association, collected the gross income, operating expenses and net income figures of 185 office buildings in over forty cities of the United States and prepared the chart shown opposite, (Chart No. 1) in which the buildings are grouped according to their heights. For each height, averages of gross income, net income and expense of the buildings in each group are shown. "It will be seen", says Mr. Shultz, "that both gross and net income increase with the height of the building to the full extent of the curve, which is twenty-four stories." Inasmuch as gross income increases faster than net income, it is apparent that a point of maximum economic return would ultimately be reached. While this study was based upon actual operating data and made by a competent student thoroughly familiar with skyscraper problems, it seems to us to be somewhat inconclusive: (1) because operating results of buildings located in many different cities under highly different conditions have been averaged and compared; and (2) because many of the high buildings were new buildings and merely because they were new and in

(1) Office Building Experience Exchange of the National Association of Building Owners and Managers, 1921, pp. 27-28.

CHART NO. 1

Effect of Height on the Gross and Net Income
185 Office Buildings



better locations, might have been paying better than the lower buildings which probably in greater proportion were old and semi-obsolete.

To sum up, then, though logic seems to indicate that the tall building *per se* is not an economic fallacy, positive assertions are persistently made to the contrary; and while attempts have been made statistically to prove the economic soundness of the skyscraper, such attempts have been inconclusive and unheeded. Even less convincing have been a number of statistical attempts to demonstrate the economic fallacy alleged to be inherent in tall buildings. It is true that in the case of many individual buildings, a very careful investigation has been made, by the prospective owner of the building, of the relative profitableness of various structures of different heights. A conspicuous illustration is the investigation made in the case of the Barclay-Vesey Building which was erected as a 32 story building only after the New York Telephone Company had caused a most elaborate study to be made of the investment possibilities of several proposed buildings of different heights. But in this as in all similar cases the data are private and confidential. We therefore decided to make a special investigation of the true "economic height" of a building on a specific site and to make the results available for public consumption and criticism. If the problem could thus be solved statistically, the public, it was thought, would cease to be confused by conflicting general claims and a sound basis would be laid for the determination of social policy. Much of the balance of this Report will be confined to a discussion of the methods and results of our special demonstration.

*Specific
Demonstration
Considered
Necessary*

As a first step in our investigation a workable definition of "economic height" was necessary. The following one suggested by J. Rowland Bibbins, ⁽¹⁾ Consulting Engineer of Washington, D. C., seemed reasonably satisfactory:

*Definition of
"Economic Height"*

"The true economic height of a structure is that height

(1) "The Economic Spiral", a paper presented May 9, 1927 at the National City Planning Conference.

which will secure the maximum ultimate return on total investment (including land) within the reasonable useful life of the structure under appropriate conditions of architectural design, efficiency of layout, light and air, 'neighborly conduct', street approaches and utility services. The balance sheet and income account should cover all elements of revenue and expense, including depreciation, obsolescence and/or amortization of structure (27 to 33 years), and also, where involved, the cost control of adjacent buildings for insuring light and air. Appreciation of land where owned, less cost of carrying the land, is properly part of the 'net return' of the enterprise. Futurities must be estimated to find the proper earning power value of the property as of any year."

It is not clear how "amortization of structure" differs from depreciation and obsolescence, and justifiable controversy may arise as to the period of 27 to 33 years allowed for the useful life of a modern structure—that period will vary widely with the circumstances of each particular property but in the case of a well-located, efficiently planned and soundly constructed modern office building the useful life should be much in excess of the figure mentioned. Further, while the real estate investor always takes into consideration the expected appreciation in land values, the accountant may refuse to estimate somewhat uncertain "futurities" for the purpose of calculating the "net return" of the enterprise. We will not consider this item in our calculations. Apart from these minor qualifications, this definition of "economic height" may be regarded as satisfactory for our purposes.

In undertaking, therefore, to make a special investigation to determine the most "economic" development of a given site, we decided upon the following conditions and methods:

*Method of
Investigation*

1. Plans and specifications were to be prepared for a number of buildings varying in height from, say, 8 or 10 stories to 75 or 100 stories; the cost of construction of each building and the total cost of the property as developed to the varying degrees of intensity were to be determined; and careful estimates of gross revenues, operating expenses, and

net income for each property, after adequate allowance for depreciation and obsolescence, were then to be prepared. Knowing the total investment and the net income in each case, it was felt that the most economic type of development would immediately become apparent and that from the data secured it would be possible to develop a curve which would probably show a trend towards "increasing returns" up to the point of maximum economic return and thereafter "diminishing returns" until ultimately a height would be reached where net income would disappear altogether.

2. A specific site was to be selected from one of the congested, high-land-value areas of New York City. On Manhattan Island, the forces which have been responsible for the development of the skyscraper are operating with their maximum intensity, and here, if anywhere, tall buildings would seem to be justified.

3. To make the study realistic and accurate, the zoning regulations of New York City as well as local conditions in regard to building costs, rental levels, traffic conditions, etc., were to be assumed as basic governing conditions.

4. The specific lot chosen was to be of sufficient size to give a fair chance to demonstrate whether under any conditions a very tall building was economically justifiable. This was necessary in order to avoid reasoning in a circle. We frequently hear the comment that such and such a proposed 75 or 100-story building is a "freak" project. Even if we should be able to demonstrate that the criticised project was economically unsound, the demonstration might merely show that the 75 or 100-story building in question was being erected on a plot that was either too small or wrongly located—not that such a building should not be built on a lot of adequate size in the right location. It should of course be obvious that the choice of a large site involves no unfairness to the low building.

5. In order to facilitate the process of estimating income, it was decided to do everything possible to design buildings whose rentable space would have a distinct advantage in the

current rental market over all other buildings. No money was to be wasted in needless ornamentation or in immoderate striving for grandeur or aesthetic effect but, short of such extremes, the utmost endeavor was to be made to secure the maximum rental appeal by painstaking search for the most adequate solution, in the case of each building, of the problems of elevator service, office depths, service facilities and efficient operating conditions.

6. To assure the most adequate solution of the architectural and other technical problems involved, to safeguard against the danger of bias on the part of the investigators, and to make the results of the study as authoritative as possible, the services of a large number of the most competent independent experts in several fields were to be requisitioned.

The carrying out of this plan of investigation resulted ultimately in the design of eight different buildings, varying in height from 8 to 75 stories, each designed as an effective architectural solution, under the assumed building height limitations, of the problem of developing a large site in the Grand Central Zone of New York City. Ground floor and typical upper floor plans for three of the eight buildings, as well as an isometric drawing and a perspective of the 75-story building, are reproduced elsewhere in this Report.

*Carrying out
the Plans*

As already stated, the only stipulation governing the choice of the specific plot to be developed, apart from its location in a high land value section of New York City, was that it should be "large enough to give a very tall building a fair chance." In other words, the plot must be large enough to carry the legally necessary sub-structure for the tower portion of the structure, which tower must in itself constitute an office building approximately ideal from the standpoint of office depths, elevator service, etc., instead of as in too many cases a "mere sliver". This condition stated in terms of planning, means that the plan at the level of transition from the setback portion to the vertical tower shaft should be of a size sufficient to accommodate the needed elevators rising

*Specific lot chosen
200' x 405'*

to that height plus a surrounding belt of rentable area approximately twenty-five feet in depth. It was obvious that the spread of the set-backs would amply provide additional interior core for the elevators, corridors and service facilities essential to the expanding space on the lower portion. For one dimension of the lot, 200 feet, or the standard north and south length of a Manhattan block, was at once determined upon. After some experimentation, it became apparent that for the other dimension of the lot, about twice this length would be feasible. Therefore, knowing that the typical block opposite the Grand Central Terminal was 200 x 405 feet, we decided to choose one of these blocks, an entire block south of the Terminal. Not only did this give us adequate area for intensive development but conditions of demand for store and office space were such as to warrant such an intensive development and, in addition, the feasibility of subway connection with the Grand Central Terminal made possible satisfactory solution of the important traffic problems involved in erecting a building of the maximum height.

*Setback
Provisions of
New York
Zoning Law*

As the setback provisions of the New York Zoning Legislation were so important in the design of our hypothetical buildings and as they constitute a limiting factor upon the economic height of building which may not be present, to the same degree at least, in other cities, it may be well to quote some of the more important clauses of Article III of the New York Building Zone Resolution. This article divides the city into various "Height Districts" and regulates the height to which a building may go on any particular site. A large portion of the high-value land of the Grand Central Terminal Zone, including our lot, is in what is there described as the "two times height district". Pertaining thereto the zoning resolution states:

Sec. 8 (g) In a two times district no building shall be erected to a height in excess of twice the width of the street, but for each one foot that the building or a portion of it sets back from the street line four feet shall be added to the height limit of such building or such portions thereof

To this general restriction there are a number of exceptions, of which the following may be cited:

Sec. 9 (a) except for the purposes of paragraph d of this section, on streets more than 100 feet in width the same height regulations shall be applied as on streets 100 feet in width.

(b) Along a narrower street near its intersection with a wider street, any building or any part of any building fronting on the narrower street within 100 feet, measured at right angles to the side of the wider street, shall be governed by the height regulations provided for the wider street. A corner building on such intersecting streets shall be governed by the height regulations provided for the wider street for 150 feet from the side of such wider street, measured along such narrower street.

(c) Above the height limit at any level for any part of a building a dormer, elevator bulkhead or other structure may be erected provided its frontage length on any given street be not greater than 60 per cent. of the length of such street frontage of such part of the building. Such frontage length of such structure at any given level shall be decreased by an amount equal to one per cent. of such street frontage of such part of the building for every foot such level is above such height limit. If there are more than one such structure, their aggregate frontage shall not exceed the frontage length above permitted at any given level.

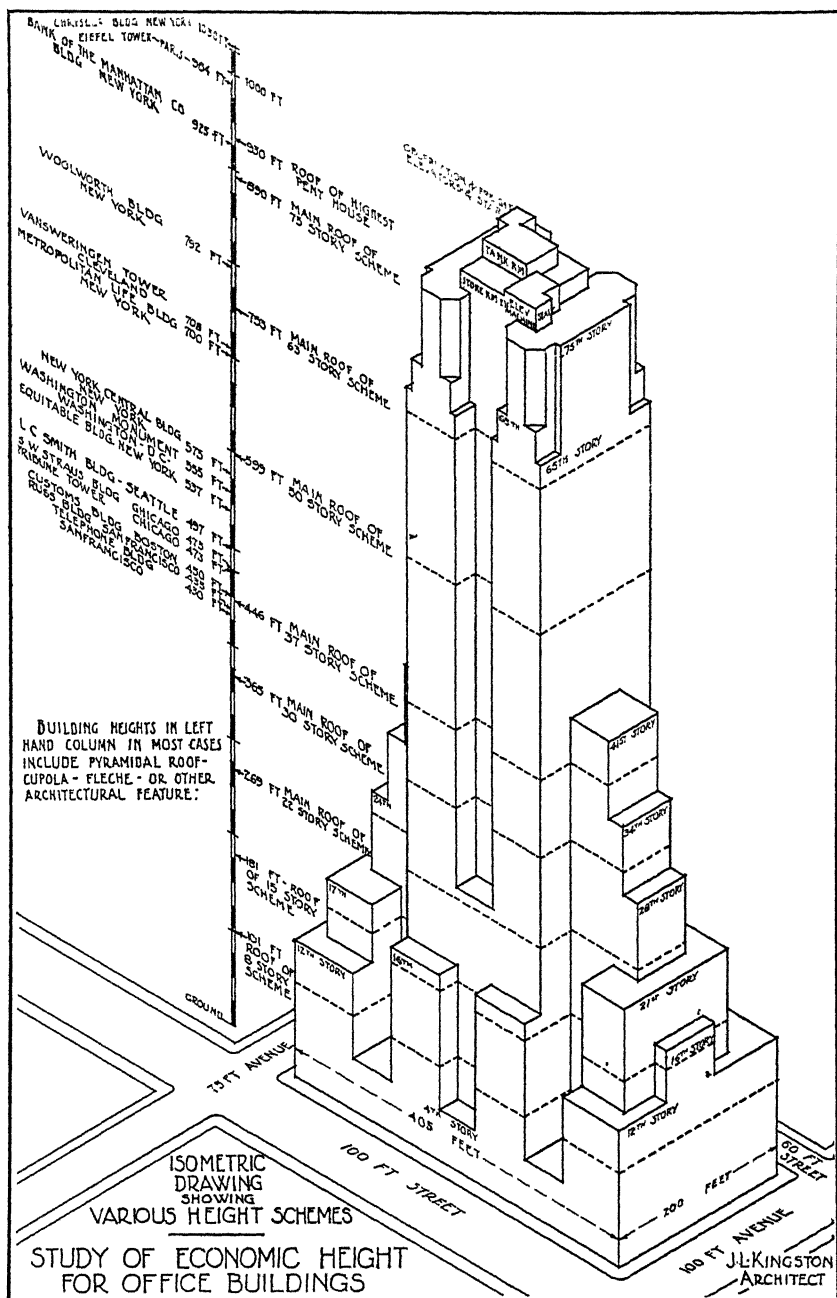
(d) If the area of the building is reduced so that above a given level it covers in the aggregate not more than 25 per cent. of the area of the lot, the building above such level shall be excepted from the foregoing provisions of this article. Such portion of the building may be erected to any height, provided that the distance which it sets back from the street line on each street on which it faces, plus half of the width of the street, equals at least 75 feet. But for each one per cent. of the width of the lot on the street line that such street wall is less in length than such width of the lot, such wall may be erected four inches nearer to the street line.

There is another clause (Article III, Sec. 9, Clause e) granting privileges to certain sites by reason of their proximity to existing buildings which were erected before the passage of the zoning resolution, but as the advantage gained by this clause is in no way general and varies with every site, it was not deemed advisable to apply it to our design.

Lack of time in the early planning stages also made it necessary to waive the privilege of the dormer clause. This is regrettable. In a building planned for erection, use would

have been made of this clause as well as of clause "e" noted on page 13, and the rentable areas of the setback portions would have been thereby perceptibly increased. The gains would have been greatest in the stories from the 15th to the 37th; therefore, the schemes for buildings of 22, 30 and 37 stories would have gained the greater percentage. But when consideration was given to the increased cost of construction and the lower rentability of somewhat deeper space, the percentage of error was considered too small to warrant the various changes in design and the upsetting of the elevator scheme which would have been necessitated by taking cognizance of the dormer clause, in the later stages of planning. While the rentable area of practically all the buildings would have been increased and while the showing of the 22-story, 30-story and 37-story would have been slightly improved, the relative standing of the buildings would not have been affected.

*Eight Buildings
Designed* In order to keep our comparison of the different buildings as closely as possible one of height, we used the same "parti" throughout, designing just one tall building and then reducing the height in various stages at the levels where the different elevator banks terminated. This gave us a series of buildings designed with the same relative degree of efficiency, the only differences between them being logical variations due to changes in height. Seventy-five stories was taken as the maximum limit of our study because we originally believed that this height was well beyond the point of maximum economic return. To determine the point at which our next building should stop we eliminated the high-rise elevators, which operate locally between the sixty-fourth and seventy-fifth stories and made the second building sixty-three stories high. Continuing this system of stepping down, we obtained a third building of 50 stories, a fourth of 37 stories, a fifth of 30 stories, a sixth of 22 stories, a seventh of 15 stories and an eighth of 8 stories. Study was given to the minimum limit of 8 stories because it has been seriously proposed in certain



quarters that New York City should limit all buildings to a height of 8 or 10 stories.

With each reduction in height, not merely were the wind bracing and the weights of the steel columns of the tower reduced but the space redeemed by the elimination of these elevators was made revenue-producing and also the service space required was slightly reduced. In the lower buildings new factors came in. For example, the large amount of valuable area added to each floor by the elimination of elevator shafts and lobbies necessitated elongation of the courts to insure adequate lighting for all the offices. This, on one side, made reductions in steel and floor slab, but on the other, added to the wall and window area and changed the ratio of rentable area to gross area and cubical content. Again, as the height and mass of the building were reduced, the sizes of the boiler room, basement service, column footings and marketable area in the basements correspondingly changed. In treating the medium and lower height buildings the space allotted to ground floor circulation was reduced as the corridors would be less densely populated. In the 8 and 15-story schemes, the expenditure for architectural elaboration, both exterior and interior, was also materially decreased. This was believed consistent with the requirements of tenants attracted to buildings of these more modest heights, and in accordance with the principle that each building was to be essentially an economic treatment of the problem in hand.

*Traffic
Problems*

As the subway and the Grand Central Terminal are in close proximity to the site studied, direct underground passage connecting these with the basement was assumed. In this way a very considerable portion of the traffic to the building would be handled without using the surface streets at all. Ample escalators were provided for those individuals using underground arteries. These escalators would mechanically connect the basement with the ground floor elevator corridor, making it in its own way a central terminal or distributing station. In the 8 and 15-story schemes the escalators were omitted. For the 22-story scheme one escalator

only, the up-going, was included, while for the higher buildings they have been shown both for up-and-down-traffic, but their width and consequent cost were varied with the height of the structure in which each was used.

On examining the ground floor elevator hall it will be seen that the width of the corridors varies with the different schemes, to give more ground floor shop space in those buildings where the traffic is less dense. It will also be noted that the banks of elevators are not arranged in regular ascending progression from end to end of the corridor. This irregular arrangement, common in large buildings, has been used so as to have the high rise elevators well within the core of the tower.

In the design of these buildings, no problem was more important or more difficult than the provision of adequate elevator service. If the evolution of structural steel design made the skyscraper possible, it was the development of the elevator which made it practicable. The height limit of rentable area is still determined by the range of efficient elevator service.

The magnitude of the problem may be indicated by the calculation that, apart from the shoppers and others entering and leaving the ground floor and basement, the tenant population of the upper floors of the 75-story building (those who use the elevators) would number upwards of 16,000 people. If this tenancy is to be of a select and permanent character, it must be assured of a safe, prompt, uninterrupted, rapid and comfortable transportation service. The most up-to-date installation was therefore specified and designed by Otis Elevator Co. It calls for multi-voltage, signal control, microlevelling cars running at a speed of from 750 to 1000 feet per minute. The use of two cars in the one shaft or of double-deck cabs serving two floors simultaneously, which may be the next developments in elevator design, would have given improved service, increased net rentable area and lowered construction cost of the higher buildings; but it was decided not to take advantage of these devices, as they had not yet

*Vertical
Transportation*

been put into actual operation. Modern practice is pretty generally agreed that for the service to be classed as A1, the intervals at which elevators leave the ground floor to every part of the building shall be not greater than 30 seconds. The Otis Elevator Company's analysis of the facilities provided in our hypothetical buildings based upon our compilation of rentable areas at various floors shows the excellent service provided. The very short interval of 13.8 seconds shown in Group 1 ⁽¹⁾ is shorter without doubt than is necessary, even for the most exacting tenant. As the problem progressed it developed that the large floor area served by this group necessitated not only using more cars than were originally provided, but also increasing the size and carrying capacity of each car.

The time intervals shown in the Otis Elevator Company's report are calculated with all up-traffic during the morning peak when filling the building, elevators descending from the upper terminals to the ground floor with operators only and without intermediate stops. The intervals are as follows:

Group 1—8	signal control elevators—1	leaves ground floor each	13.8	seconds
Group 2—6	" " " "	1 " " "	19.1	" "
Group 3—6	" " " "	1 " " "	21.5	" "
Group 4—6	" " " "	1 " " "	21.0	" "
Group 5—6	" " " "	1 " " "	23.6	" "
Group 6—8	" " " "	1 " " "	21.2	" "
Group 7—8	" " " "	1 " " "	22.9	" "
Group 8—8	" " " "	1 " " "	24.8	" "
Morning peak, average interval			21.0	" "

The intervals are calculated on the basis that the building is to be a diversified tenancy office building and that the population when the building is fully rented will correspond to 1 person per 100 sq. ft. net rentable area for floors 2 to 37

1	"	"	110	"	"	"	"	"	"	38	"	50
1	"	"	115	"	"	"	"	"	"	51	"	63
1	"	"	120	"	"	"	"	"	"	64	"	75

While the authors must accept full responsibility for any shortcomings of the plans and of the investigation generally, they gratefully acknowledge the invaluable help received

(1) Group 1 refers to the bank of elevators serving the 8 story building and the first eight floors of all other buildings, group 2 the bank serving the next seven floors, etc.

from many practical men whose professional services were enlisted in the project. Many of the leading experts in the architectural, engineering, building and management fields were approached and though the tasks assigned to them involved in many cases a large amount of work for which the normal professional remuneration would have been heavy, all agreed to cooperate to the fullest extent to the end that the correct answer should be found to a question in which all were keenly interested. Their cooperation alone made the project possible.

Thus while the plans and specifications for the eight buildings are the work of Mr. J. L. Kingston, architect, now with the firm of Sloan & Robertson, Mr. Stephen F. Voorhees, of Voorhees, Gmelin & Walker, and Mr. R. H. Shreve of Shreve, Lamb and Harmon agreed to act as an Advisory Architects Committee to bring the results of their rich architectural experience to bear upon points of architectural design and floor layout. Mr. David Lindquist, Chief Engineer of the Otis Elevator Co., agreed to supervise the design of the elevator system and to prepare an estimate of the total cost of the elevator installation.

Mr. S. F. Holtzman and Mr. David C. Coyle of Gunvald Aus Co., Consulting Engineers, and eminently qualified in problems of wind-bracing which would be obviously important in buildings of the maximum height to be designed, undertook to supervise the design of the structural steel and to calculate the tonnage required. In estimating the cost of structural steel fabrication and erection, the cooperation of the Structural Steel Board of Trade of New York, of Levering & Garrigues and of McClintic-Marshall was secured.

Mr. Otto Goldschmidt, consulting engineer, accepted a similar responsibility in so far as the mechanical equipment contracts were concerned. In this work and particularly in estimating costs he was assisted by Hatzel & Buehler for the electrical contracts and by the W. G. Cornell Co. for the plumbing, drainage and water supply systems.

For the remaining trades, quantities were taken off by

Mr. Smith of the Quantity Survey Co., while costs were estimated by the Estimating Department of Jas. Stewart & Co., General Contractors, and by the Architectural & Engineering Departments of S. W. Straus & Co.

When the plans for the eight buildings had been completed and competent estimates of their cost and of the total investment including cost of land and indirect costs had been secured, there remained the important task of obtaining reliable estimates of the net income of each property. For this purpose, two committees of New York building managers, thoroughly conversant with rental conditions in the immediate neighborhood and with costs of operating similar properties were constituted, one Committee for the purpose of estimating probable gross revenues and the other for estimating operating expenses. Among the men who consented to serve on these two committees were Mr. Lee Thompson Smith, Vice President of Pease & Elliman and President of the New York Association of Building Owners and Managers; Mr. Clarence T. Coley, Operating Manager of the Equitable Building; Mr. W. J. Demorest and Mr. C. O. Brown of Cushman & Wakefield; Mr. T. Herbert Files of Cross & Brown; and Mr. Anthony J. Bleecker, Manager of the Singer Building.

*

Summary of Results

When the plans and specifications had been completed and final estimates of construction cost, total income and operating expenses secured from the cooperating experts, it was a simple matter to determine net income and to figure this net income as a percentage of the total investment in the case of each of the eight buildings.

The results of this calculation are presented in Table No. 1 shown on the following page. The striking fact is that a height of 63 stories is discovered to be the point of maximum economic return.* The net return upon a total investment of \$22,193,000 required for the 8-story building is only 4.22%—in other words, the high land value makes such a low building unprofitable. As height increases, the net return

* See page 22.

TABLE No. 1

SUMMARY OF INVESTMENT COST, GROSS AND NET INCOME AND RETURN UPON INVESTMENT
(Assuming land value at \$200 per square foot)

	8-Story Building	15-Story Building	22-Story Building	30-Story Building	37-Story Building	50-Story Building	63-Story Building	75-Story Building
INVESTMENT			(in thousands)					
A. LAND (\$1,000 sq. ft. @ \$200).....	\$16,200	\$16,200	\$16,200	\$16,200	\$16,200	\$16,200	\$16,200	\$16,200
B. BUILDING.....	4,769	7,307	9,310	11,775	13,808	16,537	19,390	22,558
C. CARRYING CHARGES.....								
1. Interest during construction:								
(a) Land (6% on cost for full period).....	810	972	1,134	1,296	1,458	1,620	1,780	1,944
(b) Building (6% on cost for half period).....	119	219	326	471	622	826	1,065	1,313
2. Taxes during construction—Land.....	292	350	408	466	524	582	642	700
3. Insurance during construction.....	3	5	8	12	21	35	65	95
TOTAL CARRYING CHARGES.....	\$1,224	\$1,546	\$1,876	\$2,245	\$2,625	\$3,065	\$3,552	\$4,092
D. GRAND TOTAL COST.....	22,193	25,053	27,386	30,220	32,633	35,802	39,142	42,850
Total assignable to Land.....	17,402	17,522	17,422	17,562	18,182	18,404	18,622	18,844
Total assignable to Building.....	4,891	7,531	9,644	12,258	14,451	17,398	20,520	24,006
INCOME								
E. GROSS INCOME.....	1,819	2,780	3,483	4,181	4,755	5,581	6,302	6,901
F. EXPENSES:								
1. Operating.....	311	482	592	723	814	942	1,058	1,213
2. Taxes.....	479	541	591	653	725	774	846	926
3. Depreciation.....	95	146	186	235	276	331	388	451
TOTAL EXPENSES.....	\$885	\$1,169	\$1,369	\$1,611	\$1,795	\$2,047	\$2,292	\$2,590
G. NET INCOME.....	934	1,611	2,114	2,570	2,960	3,534	4,010	4,311
NET RETURN								
H. NET RETURN ON TOTAL INVESTMENT.....	4.22%	6.44%	7.73%	8.50%	9.07%	9.87%	10.25%	10.06%
I. INCREASE IN INVESTMENT FROM LAST ADDITION OF STORIES.....	.....	\$2,860	\$2,833	\$2,834	\$2,413	\$3,169	\$3,310	\$3,700
J. INCREASE IN NET INCOME RESULTING THEREFROM.....	.....	23,677	503	456	390	524	476	501
K. NET RETURN ON INCREASE IN INVESTMENT.....	.....	23.69%	21.51%	16.09%	16.15%	18.13%	14.25%	8.12%

upon the total investment shows a gradual increase from 6.44% for the 15-story building to 7.73% for the 22-story one, to 8.50% for the 30-story one, to 9.07% for the 37-story one, to 9.87% for the 50-story one, and finally to the maximum figure of 10.25% for the 63-story structure.

The dominating influence of the high land value is apparent. It is only in the 63-story structure that the total cost assignable to the land is for the first time equalled and exceeded by the total cost assignable to the building. In the 75-story building, total building cost exceeds aggregate land cost but the extra cost of constructing the last 12 stories and the loss in rentable space are so great that the average return upon the total investment is slightly less than for the 63-story building, namely 10.06%.

In this connection, the last three lines of the Table should be given consideration. They show (1) the increase in investment required to produce the last addition of stories—the added “increment” (to use the economist’s nomenclature); (2) the increase in total net income resulting from this last addition of stories; and (3) the percentage which this increase in net income is to the increase in cost. To illustrate: An 8-story building gives a net return of 4.22% upon total cost. The addition of 7 more stories would cost \$2,860,000 and would produce an increase in net income of \$677,000 or a return of 23.69% upon the extra cost. An additional 7

- * This maximum *economic* height is of course much below what might be called the maximum *physical* or *engineering* height. For all practical purposes, this physical or engineering limitation upon possible building heights has been removed by the flexibility of structural steel, terra cotta and other modern building materials and by the astounding developments in elevator and foundation engineering. Competent students of the problem estimate that if it were not for economic factors, it would be possible to erect, and operate successfully, an office building approximating two thousand feet in height. The adequate elevator servicing of such a structure would require an elevator speed beyond the present legal limits as well as new safety devices and ingenious traffic arrangements (such as double deck cabs and new combinations of express and local cars in the same shaft, which have not yet been subjected to the test of actual public trial but which, on the basis of prolonged experiment, the foremost elevator engineers believe to be entirely practicable. The two limiting factors which make it impracticable to go beyond the approximate height of 2000 feet are (1) the enormous weight of the elevator cables required, and (2) the capacity of the *average* human ear drum to withstand the vibration in an elevator cab travelling at a speed exceeding approximately 1500 feet per minute.

stories would produce a return of 21.51% upon the increased cost. The net return upon the next two "increments" of stories shows a decline because of the set-back restrictions, though it would still indicate a highly profitable investment. Above the 37-story limit these set-back regulations cease to play an important part with the result that the addition of 13 more stories is rewarded by an 18.13% return upon the extra investment. From this point on, the increasing cost of construction at great heights and a certain loss in rentable area begin to have an important effect. Thus the return upon the last 13 stories added to the 63-story building drops to 14.25% while another 12 stories would bring a return of only 8.12%.

In Chart No. 2 the percentages of net return upon total investment for various building heights are plotted in the form of a curve indicated as AA'. The second or BB' curve shown upon the chart was derived from the first or AA' curve. When it was determined that the latter was in the shape of a second degree parabola, it was a simple matter to derive an equation, by the method of least squares, that would indicate the normal trend of the curve. This equation was found to be

$$y = 2.81986 + .24985x - .0020728x^2$$

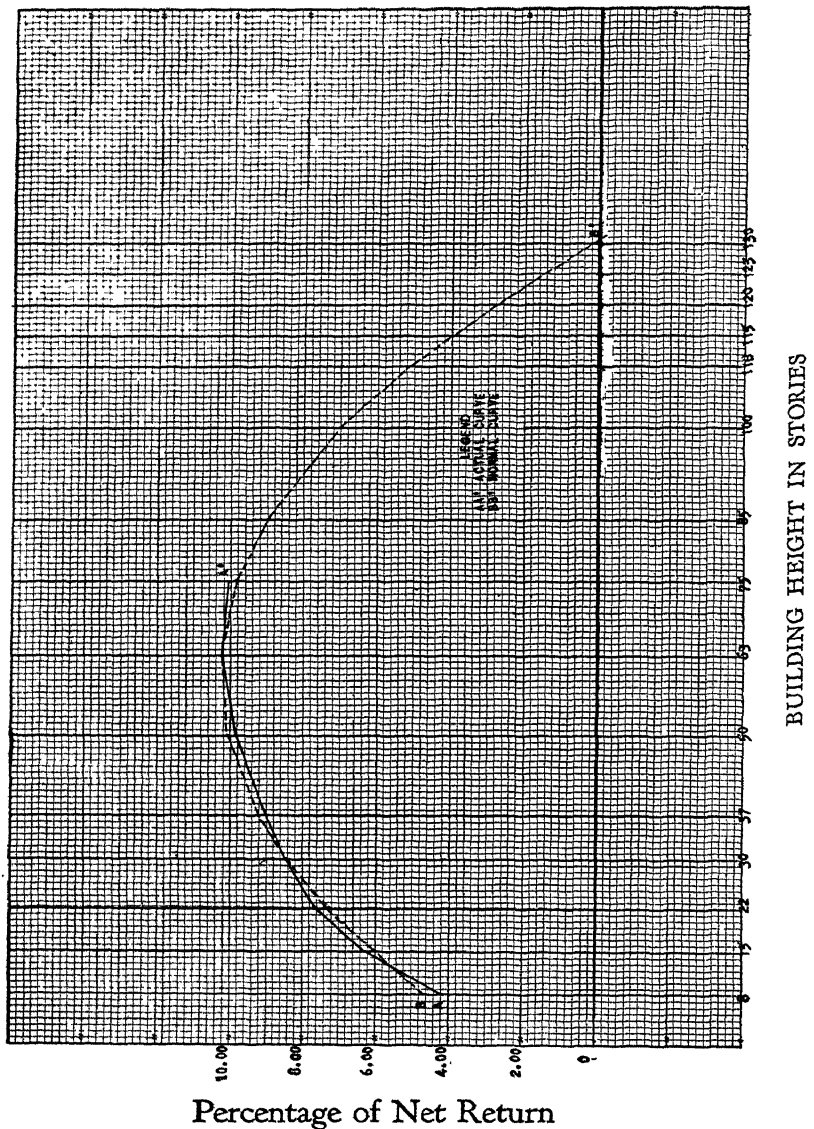
where x represents story height and y represents percentage return upon the investment. By substituting various story heights, both within and without the limits of our study, the BB' curve was determined.

The adequacy of the BB' curve is determined by the degree of scatter of the actual y values plotted in the AA' curve. That this scatter is not great is indicated by the fact that the coefficient of correlation is +.9895. A high degree of relationship between the variables therefore seems evident as perfect correlation would be indicated by a coefficient of unity.

Providing that the factors governing the relationship between story height and percentage return do not change, the equation of "best fit" may be used for estimating return upon

CHART NO. 2

Net Return Upon Total Investment for Varying Building Heights



investment for varying buildings beyond the limits of the study, with a certain degree of accuracy. The degree of accuracy of estimate is measured by the "standard error" which in this case is .2817. In other words we may normally expect that 68% of computed y values would lie within the limits of plus or minus .2817, 95% would fall within the limits of plus or minus .5634, 99.7% would fall within the limits of plus or minus .8451, from the line of best fit.

The following table (Table No. 2) of building heights and percentage return upon investment is obtained from substituting various building heights in the normal equation above.

TABLE No. 2

TABLE SHOWING RELATIONSHIP BETWEEN BUILDING HEIGHT AND PERCENTAGE RETURN UPON INVESTMENT: (A) ACTUAL RESULTS AND (B) NORMAL PERCENTAGES COMPUTED FROM EQUATION OF BEST FIT

(Assuming land value at \$200 per square foot)

Story Height	A	B
	Actual Percentage Return Upon Total Investment	Normal Computed Percentage Return Upon Investment
8	4.22%	4.69%
15	6.44%	6.10%
22	7.73%	7.31%
30	8.50%	8.45%
37	9.07%	9.23%
50	9.87%	10.13%
63	10.25%	10.33%
75	10.06%	9.90%
85	.....	9.08%
100	.....	7.08%
110	.....	5.22%
115	.....	4.14%
120	.....	2.95%
125	.....	1.66%
130	.....	-.27%
131	.....	-.02%

These percentages are only estimates based on the results of our study and subject to the degree of accuracy indicated above. It is interesting to note that apparently the tendency to diminishing returns would continue until net income would vanish altogether at a height of 131 stories.

Caution must be used, however, in projecting the curve beyond the limits of our study, and particularly in attempting

*Caution
Necessary in
Applying Formula*

to apply the formula to other sites. It is clear, for instance—and this point will be discussed more fully later—that if a smaller plot and one of lower value had been selected, the tendency to diminishing returns would have been more rapid and the point of maximum economic return would have been reached much earlier than in the case of the approximately ideal lot which was actually chosen. It therefore cannot be too strongly emphasized that each building plot presents an individual architectural problem which must be solved by careful study of a complicated set of physical and economic factors peculiar to the particular plot at the time when it is proposed to develop it. Nevertheless, of one thing we can be reasonably sure, and that is that no matter what the size or value or location of the plot or the character of the building, the law of diminishing returns will set in at some story height and sooner or later a point will be reached beyond which it will not pay the owner to build under the existing conditions. This point of maximum economic return in the case of strategic, high-value locations in our metropolitan centres is considerably higher than many critics had assumed, but it is always present.

Another word of caution is perhaps desirable. As this investigation was essentially statistical in character, the results are necessarily presented in mathematical terms. It is not the intention of the authors, however, to insist on the precise mathematical accuracy of our conclusions. We realize for instance that had a larger technical staff and more time been available we might have improved the building plans, increased the net rentable areas and probably made some slight variations in the estimate of certain items of construction cost. We realize that such further study might have moved the point of maximum economic return a few stories. We are confident, however, that any such change in the point of maximum economic return would have been upward rather than downward, and that our conclusions are in general conservative.

Detailed Analysis of Results — Factors Responsible for Tendency to Diminishing Returns.

As important as the discovery of what is the true "economic height" in a given case is the answer to the question of why the maximum economic return upon investment is reached at that particular point. Detailed examination of the results of our investigation reveals a multitude of causal factors bearing upon the net return to be received from an investment in a modern building. Some of these factors tend to produce increasing returns as height increases; others tend towards diminishing returns, while still others are either irregular or more or less constant in their effect. The combination of these conflicting factors or forces results in a definite tendency to increasing returns until a considerable height is reached, after which point (the point of maximum economic return), the percentage of net income from the required investment steadily decreases.

Among the more important factors are the following:

1. Value of the land.
2. Size and shape of plot.
3. Legal restrictions.
4. Efficiency of architectural design and layout.
5. Building factors showing tendency to increasing cost.
 - (1) Structural steel
 - (2) Elevators
 - (3) Brickwork
 - (4) Plumbing and water supply
 - (5) Heating and ventilating
 - (6) Electric light and power wiring
 - (7) Total mechanical equipment
 - (8) Permanent interior partitions
 - (9) Windows and glazing
6. Building factors showing tendency to decreasing cost.
 - (1) Roofing
 - (2) Excavations and foundations
 - (3) Miscellaneous

7. Building factors showing tendency to constant cost.
 - (1) Interior finish
 - (2) Concrete floors
 - (3) Exterior finish
8. Absorption of rentable area by elevators and other service facilities.
9. Level of construction costs.
10. Variations in rental value of floors at various heights.
11. Variations in operating costs at various heights.

The relative importance of a number of these factors as revealed by our investigation will be considered in some detail in the remainder of this Section.

1. VALUE OF THE PLOT.

Land Value It is apparent from even a cursory examination of Table No. 1 that the role played in our problem by the high cost of the land is a dominating one. It is difficult to say at what figure a plot of this large size in this area could actually be assembled. For our primary calculations, an average price of \$200 per square foot or a total land value of \$16,200,000 was assumed. Purchase and lease transactions which had taken place in the immediate neighborhood a short time before the study was undertaken seemed to indicate that this assumed figure represented a very conservative value at the time. Indeed, unless a cooperative arrangement could have been effected among the existing holders of large portions of the site, it might have been difficult to assemble the entire plot for even \$300 per square foot. As will be seen, however, any underestimate of the cost of the land would redound to the disadvantage of the higher buildings in the comparison with the lower structures.

An important element in the cost of the land and of the whole property is the cost of carrying the land as an unproductive asset during the construction period. Taxes paid and interest foregone during this unproductive period are costs which should be added to the original purchase price of the land. The longer the construction period, the more important

does this item become. This factor, therefore, works to the disadvantage of the taller buildings which require a longer time to erect. Thus in the case of the 75 story structure, interest and taxes upon the land during the two years required to construct the building add \$2,644,000 or 16.3% to the original cost of the land as compared with just half this much in the case of the 15 story building⁽¹⁾.

As already pointed out, it is only in the 63 story building or the building representing true economic height that total cost assignable to the building for the first time exceeds the total cost assignable to the land. This precise coincidence may be merely accidental; further experimentation would be necessary to determine this point. It is clear, however, that in the lower buildings the relation between land and building cost is too unbalanced to make possible a profitable investment. What we might call the "overhead" of land cost is much too great for the small volume of business which the net rentable area produced by 8 or 15 or 22 stories makes possible. The addition of more stories serves to spread this land overhead progressively thinner over each unit of business done; however, after a time this gain is partly, and then wholly, neutralized by other factors which increase the cost of doing the larger volume of business. This is precisely the answer which a deductive consideration of the problem of building height suggested to us. Our statistical demonstration has merely tended to confirm it and make it more precise.

The practical significance of this conclusion is that in the strategic centres of our metropolitan cities where land values are high and are daily being pushed higher by the working of the law of supply and demand, the private owner of an office building site *must* build a skyscraper—must develop his land to its maximum economic intensity if he is to have a profitable investment. Not only that, but the higher the value

(1) A number of construction records made during 1929 seem to indicate that the time allowed for the construction of our tall buildings (2 years for the 75 story structure) could be considerably shortened. This is one of a number of ways in which our calculations are somewhat unfair to the taller buildings.

of his land, the higher he must go. We were able to demonstrate the truth of this corollary by substituting in our master table other values for the land and making the necessary adjustments. It was found that with land at \$400 a square foot and higher, the 75 story structure rather than the 63 story one represented the point of maximum economic return. The proof of this corollary is to be found in the following table (Table No. 3) which shows the net return upon the investment in our eight buildings assuming varying land values.

TABLE No. 3
NET RETURN ON INVESTMENT WITH VARYING
LAND VALUES

<i>Buildings</i>	<i>LAND VALUES</i>					
	<i>\$100 Per Sq. Ft.</i>	<i>\$200 Per Sq. Ft.</i>	<i>\$300 Per Sq. Ft.</i>	<i>\$400 Per Sq. Ft.</i>	<i>\$500 Per Sq. Ft.</i>	<i>\$600 Per Sq. Ft.</i>
	<i>Per Cent</i>	<i>Per Cent</i>	<i>Per Cent</i>	<i>Per Cent</i>	<i>Per Cent</i>	<i>Per Cent</i>
8 Stories.....	8.29	4.22	2.42	1.42	.77	.33
15 Stories.....	11.05	6.44	4.21	2.90	2.04	1.43
22 Stories.....	12.45	7.73	5.31	3.83	2.85	2.14
30 Stories.....	13.10	8.50	6.06	4.54	3.48	2.72
37 Stories.....	13.40	9.07	6.62	5.04	3.96	3.11
50 Stories.....	14.04	9.87	7.42	5.78	4.63	3.77
63 Stories.....	14.10	10.25	7.86	6.26	5.08	4.20
75 Stories....	13.50	10.06	7.83	6.33	5.21	4.32

It will be noted that, with land at \$100 to \$300 per square foot the maximum return upon total investment is reached in the 63 story building, with land at \$400 per square foot and higher, one must erect a structure of 75 stories to secure the maximum economic return. This is of course only what the economist would expect from the familiar doctrine of economic rent. High land value reflects the possibility of high returns.

This table would be considerably altered in favor of the taller buildings, were the income from ground floor shops increased to reflect the increasing values of land assumed. Though such a correction would have been entirely justifiable our estimates of income were not recomputed to take account of this factor.

If the conclusions of this Section be correct, then any attempt to restrict building heights arbitrarily to 8 or 10 or

20 stories, as has been proposed by some city planning enthusiasts who profess to find the source of nearly all human ills in the centralized city, would result in a severe deflation of land values in the central business districts of our leading cities. Such deflation would have disastrous consequences, as the whole economic fabric of society is built up to an important degree upon the current values of city property. In the words ⁽¹⁾ of George C. Nimmons, who is a critic of the skyscraper but who nevertheless realizes the financial effect of drastic limitation of building heights—"Industry, commerce and business are deeply involved. Investments of a large part of our wealth are tied up in city property. Credit extended by the banks is largely secured by the important pieces of property, and many people are holders of securities which have an interest in city property. If then building heights are generally cut down over the country to a point which would materially lower the present earning power of city property, it is almost certain that there would be a panic and that thousands of people would fail". An important additional effect would be the deflation and dislocation of the whole tax structure of our cities which raise so large a proportion of their total revenue by taxes upon real estate. As will be explained later, the deflation of land values in the central business districts would not be offset by corresponding appreciation elsewhere, for the decentralized city will be found to be not only a less efficient but probably also a more expensive mechanism for carrying on commercial and certain (though by no means all) types of industrial activity.

Before passing from consideration of land value which is perhaps the most important single factor bearing upon the problem of economic height, we present Table No. 4 which shows the net income from ground floor shops, basement and sub-basement and the percentage of such income to investment in land. It is a well-known rule of thumb that such income should "carry" the cost of the land. While we believe

(1) Studies on Building Height Limitations in Large Cities (published by the Chicago Real Estate Board, 1923), page 103.

TABLE No. 4

<i>Height in Stories</i>	<i>Gross Income from Ground Floor Shops, Basement and Sub-Basement</i>	<i>Return on Bare Cost of Land (\$16,200,000)</i>	<i>Return on Total Costs Assignable to Land</i>
8 Stories.....	\$845,000	5.22%	4.88%
15 Stories.....	864,000	5.34%	4.93%
22 Stories.....	895,000	5.52%	5.04%
30 Stories.....	957,000	5.90%	5.34%
37 Stories.....	973,000	6.00%	5.36%
50 Stories.....	1,057,000	6.53%	5.76%
63 Stories.....	1,073,000	6.62%	5.77%
75 Stories.....	1,083,000	6.68%	5.75%

that this crude formula has no scientific basis and is a convenient rule only in a limited range of cases, we present the table for those who may be used to this method of analysis and because the data may be of some interest in themselves.

2. SIZE AND SHAPE OF LOT

It is probably safe to say that second only to land value as a factor in determining the economic height of a building are the size and shape of the plot. Perhaps, indeed, these factors should be ranked as first in importance.

Their influence on building height scarcely needs any demonstration. It seems obvious that, under any conditions and particularly under the set-back provisions of a modern zoning law, a small lot would reach its point of maximum economic development at a much lower level than a considerably larger lot. Elevator and service facilities call for more space and more cost as height increases; the smaller the lot the sooner does this demand reach a prohibitive ratio to the net amount of rentable area. Similarly the smaller the lot, the sooner do the set-back requirements pinch down the net amount of rentable area to unprofitable dimensions. If the lot is small, a tower restricted to 25% of the lot area is likely to be uneconomic. This is too frequently the case in actual practice. Many sites are actually developed beyond their point of maximum economic return and this fact is probably what has led certain critics to direct the economic fallacy argument against the skyscraper. The economic fallacy of some tall buildings they have interpreted as the economic fallacy of *all* tall buildings.

*Limitations of
Small Plot*

It seems equally obvious that the shape of the lot must be such as to lend itself to intensive development. An irregular lot or too narrow a lot gives rise to difficulties of design which usually increase as height increases.

For the purposes of our investigation, a lot size of 200 feet by 405 feet was deliberately selected because it was thought to represent an area approximately ideal for intensive development. The soundness of this assumption was amply demonstrated during the process of preparing the plans and working out the estimates of cost and income. The straightforwardness and efficiency of design which an inspection of the plans will reveal, the approximately ideal character of the office floor plan throughout most of the building, the assurance of permanent light and air for most of the space, and the relative economy of construction (for instance, for many important building factors such as structural steel) were made possible by the size and shape of the particular lot.

Such results tended to confirm our conviction that the real estate trend of the future, particularly in the central sections of our leading cities, will be inevitably in the direction of development in larger units, such as entire city blocks. Such development will not only contribute enormously to greater economic returns to the individual property owner but will also make possible a more aesthetic design of individual buildings as well as a more harmonious and more socially efficient grouping of buildings.

This is one of the answers to a criticism which may be made of our investigation, namely, that it was based on a plot of abnormal size. Another reason has already been given—such a plot was chosen to avoid reasoning in a circle. Had sufficient time been available, it would have been interesting and valuable *also* to have made a similar investigation for a plot of the type which in the past has been more frequently developed, for instance, a plot 200 feet long by 100 feet or 200 feet in width. On such a plot in such a location, we would probably have found that the economic height was somewhere around 40 or 50 stories. The conclusion would

then have been that if we were restricted to a lot of the smaller size we should build to a height of "somewhere around 40 or 50 stories" but that on grounds of both individual profit and social desirability the most efficient development would be the development of the entire city block to a height of approximately 63 stories.

Two practical objections to this type of urban development may be mentioned: (1) the practical difficulty of assembling plots of this size in an established metropolitan centre; and (2) the greater difficulty of adjusting supply to demand where such large units are thrown upon the rental market at one time. These objections have some practical importance but are by no means conclusive.

It is difficult, of course, to assemble a full city block in the heart of New York or Chicago and the cost of procuring a strategic corner or an already highly developed lot may be enormous. But in the first place, it should be noted that if the greater efficiency of the larger unit can be demonstrated a higher average square foot value can be paid. In the second place, an answer to such difficulties may be found in the co-operative device. If the city block is held by three or four important owners, it may be possible to convince each of these holders to throw his parcel into a single plot for joint development on the theory that a third interest in an efficient development of the entire block will be immensely more profitable than the entire return on a necessarily inadequate development of one-third of the block.

Turning to the second point, it must be admitted that development in larger units will undoubtedly increase to some extent the difficulty of making a smooth adjustment of supply and demand in the rental market. On the other hand, if and as the large unit development becomes typical, ownership is bound to be in more responsible hands and, therefore, a more scientific determination of supply and demand conditions will be made before each new enterprise is begun. Further, a large proportion of the space is likely to be contracted for by large corporations in the early stages of planning

(possibly as the result of some such cooperative arrangement as was suggested above), and for the rest, the longer period of construction will automatically allow a more scientific rental campaign running over a longer period of time.

In this connection it should be noted that an important factor bearing upon the determination of economic height is the amount of net rentable area to be thrown upon the market considered in relation to the current vacancy situation and the community's rate of absorption of new office space. In our specific investigation we abstracted this factor from the problem by endeavoring to assure such a differential in rental appeal of our new buildings over competitive buildings that all doubt of their ability to rent up quickly would be removed. We followed this procedure in order to avoid the endless controversy which would follow any attempt to assign arbitrary estimates of probable relative durations of rental campaigns and probable relative vacancy percentages for our various buildings. Some persons, for instance, would argue that the low buildings would be "rented up" more quickly than the others because they would throw such a limited amount of space upon the market; others would maintain with equal vehemence and show of logic that the superior rental appeal of the tall buildings and their probable ability to secure the cooperation of one or more large corporations as tenants or owner-tenants would lead them to "rent up" more quickly and more completely. The answer would be indeterminate, hence the decision to provide such superiority in layout and accommodations as to assure rapid and complete absorption of the new space in all cases.

But while this factor was eliminated in our investigation, it is none the less one that calls for careful consideration whenever a new office building is to be erected. For it is obvious that if the erection of a very tall building would throw on the rental market such a large amount of space of such a character that several years would be required for the market to absorb it, then the cost of carrying this unproductive vacant space would have to be absorbed as a capital cost.

Careful estimates of this factor of cost should therefore be included in scheduling the comparative costs and earning possibilities of the several alternative structures which might be erected upon a given site.

3. LEGAL RESTRICTIONS

Legal limitations upon the free development of building sites may be one of the most important factors determining the economic height of buildings. If the provisions of the local Zoning Ordinance and Building Code are severe, the economic limit will probably be reached at a moderate height on most building sites. If no such arbitrary restrictions exist and purely economic factors are allowed to govern, true economic height will be found at a somewhat higher level, probably a considerably higher level.

*New York's
Setback
Regulations* In New York City, the "setback" requirements of the Zoning Ordinance are somewhat more drastic than the corresponding regulations in many other American cities. Their chief provisions have been quoted in an earlier section of this paper. That they not only have revolutionized our metropolitan architecture but also have exercised an important restraining influence upon the height of our newer office buildings is evident from a study of our plans and from the table, (Table No. 5), page 37, showing gross area for typical floors in our various buildings.

Of course not all the reduction in the gross area of the upper floors can be attributed to the setback regulations. Without any legal restrictions whatsoever, some voluntary sacrifices in floor area would have been made in order to assure adequate light and air, and in order to maintain an approximately ideal office depth of 25 feet. These, however, would have been of minor consequence as compared with the enforced surrender of three-quarters of the lot area for the floors above the 43rd story.

Further light on the influence of the setback regulations may be gained by contrasting the 1,220,688 square feet of net rentable area in the Equitable Building on lower Broadway, New York City, which, because it was built in 1912,

TABLE No. 5
GROSS FLOOR AREAS

Average Gross Area Per Floor	8-Story Building sq. ft.	15-Story Building sq. ft.	22-Story Building sq. ft.	30-Story Building sq. ft.	37-Story Building sq. ft.	50-Story Building sq. ft.	63-Story Building sq. ft.	75-Story Building sq. ft.
Ground Floor.....	81,000	81,000	81,000	81,000	81,000	81,000	81,000	81,000
2nd to 8th Floors.....	71,150	71,138	71,135	71,103	71,868	71,868	71,868	71,868
9th to 15th Floors.....	....	56,454	56,451	56,406	57,476	57,476	57,476	57,476
16th to 22nd Floors.....	....	....	38,271	38,226	39,296	39,296	39,296	39,296
23rd to 30th Floors.....	....	....	....	29,533	29,666	29,666	20,666	20,666
31st to 37th Floors.....	....	....	....	....	26,290	26,290	26,290	26,290
38th to 50th Floors.....	....	....	....	....	....	21,159	21,159	21,159
51st to 63rd Floors.....	....	....	....	....	....	....	20,169	20,169
64th to 75th Floors.....	....	....	....	....	....	....	....	18,572

*Rough Estimate
of Loss in
Rentable Area
Due to Setbacks*

risers without any setbacks to a height of 40 stories on its various street frontages, with the 1,313,346 square feet of net rentable area in our 37 story building. This comparable area is obtained by developing, without setback restrictions, a plot which has only 60% of the area of the plot we selected for our demonstrations. In office depths and other service standards, the two buildings are generally comparable. Making rough allowances for the differences in lot sizes and in number of floors, we estimate that the present setback regulations caused a loss in net rentable area of about 34% in our 37 story building. If the Equitable Building had been built to a height of 75 stories, it would have had a net rentable area of just over 2,000,000 square feet less a certain additional wastage of area caused by the extra elevators required. On this basis and after making rough corrections for elevator wastage and for lot sizes, it would seem that in the case of our 75 story structure, the loss of net rentable area due to setback regulations is approximately 48%.

The sacrifice of individual income caused by the setback laws is apparently a heavy one; it is not so great, however, when one considers the effect on any given property of an unrestricted development of all surrounding properties. Though controversy may still exist as to details, New York City accepts the general principle of setback legislation as contributing to the greatest good of the greatest number.

4. EFFICIENCY OF ARCHITECTURAL DESIGN AND LAYOUT

It is apparent that the degree of efficiency used in designing the building, preparing the plans and specifications, etc., will have some bearing upon the point at which the maximum economic return is reached. Inefficiency in this respect will affect all buildings of whatever height, but it will be particularly important in the tall buildings. An inadequate elevator solution or a wasteful floor layout will become increasingly burdensome as height increases.

Architectural efficiency is difficult to measure in precise statistical terms. In part to throw some light on the planning efficiency of our eight buildings and in part merely as a mat-

ter of record, we present at this point Table No. 6 which gives a number of interesting facts in regard to the various hypothetical buildings. Of special interest are the items showing the percentage of net rentable area to gross floor area, the percentage of net rentable area to gross lot area and the number of cubic feet required to make 1 square foot of net rentable area in the case of each building. For a building as high as 63 stories, particularly with our 25 foot office depth, a 67.5 percentage of net rentable area to gross floor area is considered as a high average rentable efficiency while with our assumed ceiling heights, a requirement of 17.85 cubic feet to produce 1 square foot of net rentable area is regarded as similarly efficient. If we had assumed an office depth of 27 or 28 feet which is commonly found even in the highest grade office buildings and if we had used a slightly lower ceiling height, we would have materially increased our net rentable areas, reduced our cubical contents and considerably improved the ratios of net rentable area to gross area and of cubic contents to net rentable area.

*Measures of
Efficiency in
Architectural
Design*

In Table No. 7 more complete data in regard to net rentable area by floors for each building are presented.

Table No. 8 is designed to reveal the relationships between cubic foot contents and net rentable areas for the various buildings. These relationships it is important to keep in mind in analyzing the effect of design on costs per square foot and per cubic foot not only for each building as an entirety, but also for each of the major items of construction cost to be considered in succeeding paragraphs of this section.

*Relationship of
Net Rentable
Areas and
Cubical
Contents*

It will be noted that the increase in the cubical content of the 15 story building over the 8 story building is 52.2% as against an increase of 56.5% in net rentable area. The percentages of increase after the 15 story are almost always greater per cubic foot than they are per square foot. This is because of the fact that the space taken up by elevators and other service facilities is an increasingly large proportion of the total space available. The effect of the setback laws on

TABLE No. 6
PHYSICAL DESCRIPTION OF BUILDINGS

	8-Story Building	15-Story Building	22-Story Building	30-Story Building	37-Story Building	50-Story Building	63-Story Building	75-Story Building
Height in Feet.....	114' 9"	194' 8"	283' 0"	392' 6"	473' 0"	626' 6"	780' 0"	918' 0"
Cubical Contents (Cu. Ft.).....	8,554,482	13,629,450	16,877,084	20,039,266	22,473,610	26,027,910	29,516,283	32,079,149
Gross Floor Area (Sq. Ft.).....	675,673	1,070,778	1,389,470	1,647,388	1,878,631	2,157,859	2,444,212	2,689,210
Net Rentable Area (Sq. Ft.).....	513,420	803,102	983,806	1,165,862	1,313,346	1,491,259	1,653,342	1,791,924
Office Space.....	401,494	692,736	875,780	1,036,896	1,175,240	1,345,233	1,500,996	1,640,258
Basement.....	56,639	55,859	54,889	54,889	54,889	54,889	54,889	54,889
Basement Per Floor.....	56,639	55,859	54,889	54,889	54,889	54,889	54,889	54,889
Rentable Efficiency*.....	76.0%	75.0%	70.99%	70.79%	69.99%	69.99%	69.99%	69.99%
Average Net Rentable Area Per Office Floor (Sq. Ft.).....	57,356	49,481	41,704	35,755	32,665	27,468	24,195	22,172
Gross Lot Area (Sq. Ft.).....	81,000	81,000	81,000	81,000	81,000	81,000	81,000	81,000
Average Net Rentable Area Per Office Floor to Gross Lot Area.....	70.9%	61.1%	51.5%	44.3%	40.4%	33.9%	29.9%	27.4%
Cubic Feet to Make 1 Square Foot of Net Rentable Area.....	17.44	16.97	17.15	17.19	17.11	17.45	17.85	17.90
Number of Elevators.....	8	14	20	26	32	40	48	56
Passenger.....	2	2	4	4	1	1	1	1
Freight.....	1	1	1	1	1	1	1	1
Escalators.....	10	16	21	31	37	42	52	62

*Percentage of net rentable area to gross floor area. (Gross floor area is calculated to plaster line of wall, wall being 18" thick; net rentable area is measured after allowing for minimum tenant sublet width.)

TABLE No. 7
NET RENTABLE AREA BY FLOORS
(In square feet)

	8-Story Building	15-Story Building	22-Story Building	30-Story Building	37-Story Building	50-Story Building	63-Story Building	75-Story Building
Sub-Basement.....	56,639	55,859	54,889	54,889	54,889	54,889	54,889	54,889
Basement Floor.....	56,639	55,859	54,889	54,889	54,889	54,889	54,889	54,889
Basement Per Floor.....	56,639	55,859	54,889	54,889	54,889	54,889	54,889	54,889
2nd Floor Through 8th Floor.....	401,494	398,428	393,935	390,732	393,100	389,124	385,148	386,707
Total.....	401,494	398,428	393,935	390,732	393,100	389,124	385,148	386,707
9th Floor Through 15th Floor.....	401,494	398,428	393,935	390,732	393,100	389,124	385,148	386,707
Total.....	401,494	398,428	393,935	390,732	393,100	389,124	385,148	386,707
16th Floor Through 22nd Floor.....	401,494	398,428	393,935	390,732	393,100	389,124	385,148	386,707
Total.....	401,494	398,428	393,935	390,732	393,100	389,124	385,148	386,707
23rd Floor Through 30th Floor.....	401,494	398,428	393,935	390,732	393,100	389,124	385,148	386,707
Total.....	401,494	398,428	393,935	390,732	393,100	389,124	385,148	386,707
31st Floor Through 37th Floor.....	401,494	398,428	393,935	390,732	393,100	389,124	385,148	386,707
Total.....	401,494	398,428	393,935	390,732	393,100	389,124	385,148	386,707
38th Floor Through 50th Floor.....	401,494	398,428	393,935	390,732	393,100	389,124	385,148	386,707
Total.....	401,494	398,428	393,935	390,732	393,100	389,124	385,148	386,707
51st Floor Through 63rd Floor.....	401,494	398,428	393,935	390,732	393,100	389,124	385,148	386,707
Total.....	401,494	398,428	393,935	390,732	393,100	389,124	385,148	386,707
64th Floor Through 75th Floor.....	401,494	398,428	393,935	390,732	393,100	389,124	385,148	386,707
Total.....	401,494	398,428	393,935	390,732	393,100	389,124	385,148	386,707
Average Net Rentable Area in Various Buildings.....	513,420	803,102	983,806	1,165,862	1,313,346	1,491,259	1,653,342	1,791,924
Total Net Rentable Area in Office Floors.....	401,494	692,736	875,780	1,036,896	1,175,240	1,345,233	1,500,996	1,640,258
Average Net Rentable Area Per Office Floor.....	51,342	49,481	41,704	35,755	32,665	27,468	24,195	22,172

TABLE No. 8
ANALYSIS OF NET RENTABLE AREAS AND CUBICAL CONTENTS OF VARIOUS BUILDINGS

BUILDING	NET RENTABLE AREA		INCREASE IN RENTABLE AREA		CUBICAL CONTENTS		INCREASE IN CUBICAL CONTENTS	
	Square Feet	Relatives	Square Feet	Percentage Increase	Cubic Feet	Relatives	Cubic Feet	Percentage Increase
8 Stories.. .. .	513,420	100		.	8,954,482	100		.
15 Stories.. .. .	803,102	157	289,662	56.5%	13,629,450	152	4,674,968	52.2%
22 Stories.. .. .	983,806	192	180,704	22.5%	16,877,084	189	3,247,634	23.8%
30 Stories.. .. .	1,165,862	227	182,056	18.5%	20,039,266	223	3,162,182	18.8%
37 Stories.. .. .	1,313,346	256	147,484	12.6%	22,473,610	251	2,434,344	12.2%
50 Stories.. .. .	1,491,259	291	177,913	13.5%	26,027,910	291	3,554,300	15.8%
63 Stories.. .. .	1,653,342	322	162,083	10.9%	29,516,283	330	3,488,373	13.4%
75 Stories.. .. .	1,791,914	350	138,572	8.4%	32,079,149	358	2,562,866	8.7%

cubical contents and net rentable areas may also be determined by an examination of these figures, which show that the percentages of rentable area and cubical content added by increasing height steadily decrease as height increases.

It is important to bear these relationships in mind when studying the costs per square foot of rentable area and cost per cubic foot for each of the major component parts of the building to be considered individually later. Those items showing a steady upward trend, rapidly increasing from the 8 to the 15 story building and showing more gradual increases thereafter, will be those which depend largely upon the areas themselves. There will however be other items of cost which will show constant trends or downward trends or abrupt upward trends; this indicates that there are other causal factors peculiar to each item which cause deviations from the normal.

5. BUILDING FACTORS SHOWING TENDENCY TO INCREASING COST.

Total building cost per square foot of net rentable area is plotted as one of the curves in Chart No. 3. This item is lower for the 15 story building than for the 8 story scheme, largely because the cost of excavations, of ground floor corridors, and of the cut stone work of the first few stories is spread over a larger area. But from the 15 story building upward, building cost per square foot of net rentable area shows a steadily rising trend.

Total building cost, however, is made up of many items. If this total be broken down into its principal component parts, it will be found that some factors of building cost show a rapidly rising trend as height increases; a number rise steadily but not quite as rapidly; others show a declining tendency; while still others either fluctuate irregularly or follow a fairly constant trend.

Before considering the individual factors in detail, it may be well to present the following summary tables which show (1) total building cost in dollar volume broken down for a number of important component factors (Table No. 9), (2) cost per square foot of net rentable area for each of these

CHART NO. 3

Cost Per Square Foot of Net Rentable Area
Total Investment and Its Component Parts.

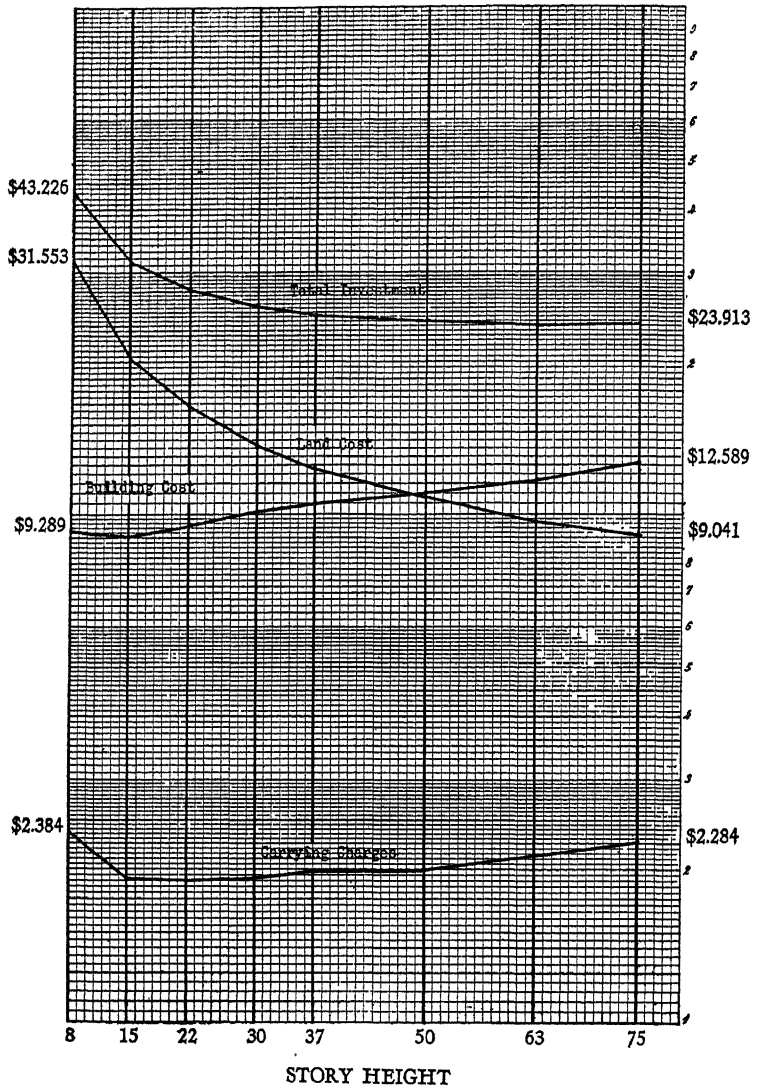


TABLE No. 9
BUILDING COST BY CHIEF COMPONENT FACTORS
(000 omitted)

<i>Trades</i>	<i>8 Stories</i>	<i>15 Stories</i>	<i>22 Stories</i>	<i>30 Stories</i>	<i>37 Stories</i>	<i>50 Stories</i>	<i>63 Stories</i>	<i>75 Stories</i>
EXCAVATIONS AND FOUNDATIONS.....	\$379	\$382	\$393	\$481	\$571	\$653	\$743	\$744
STRUCTURAL STEEL.....	368	641	855	1,110	1,325	1,717	2,233	3,093
CONCRETE FLOORS AND FINISH.....	312	466	566	667	766	899	1,033	1,151
PERMANENT INTERIOR AND PARTITIONS.....	115	187	232	320	376	478	589	692
BRICKWORK.....	91	202	319	430	539	703	851	988
EXTERIOR FINISH (Stone, Terracotta, Copper and Bronze, etc.)	204	399	507	619	679	757	836	922
ROOFING.....	31	46	47	47	49	53	53	53
WINDOWS AND GLAZING.....	98	147	192	234	274	329	381	429
INTERIOR FINISH AND TRIM.....	935	1,402	1,756	2,103	2,368	2,756	3,131	3,423
MECHANICAL EQUIPMENT.....	906	1,456	2,021	2,825	3,545	4,436	5,404	6,493
(a) Elevators and Elevator Fronts.....	315	523	854	1,080	1,450	1,856	2,328	2,967
(b) Plumbing, Drainage and Water Supply.....	223	402	523	661	842	995	1,186	1,370
(c) Electric Light and Power, Wiring and Fixtures..	138	245	318	410	478	572	664	750
(d) Heating and Ventilating.....	230	286	326	374	475	1,013	1,226	1,406
TENANTS' CHANGES.....	305	532	676	816	920	1,042	1,146	1,232
MISCELLANEOUS.....	204	230	240	360	368	382	394	407
TOTAL.....	3,948	6,090	7,824	10,012	11,780	14,205	16,794	19,627
PLANT AND GENERAL CONDITIONS.....	247	341	407	500	572	668	772	882
EXTRAS AND CONTINGENCIES.....	118	180	219	254	285	325	363	393
TOTAL DIRECT LABOR AND MATERIAL COST.....	4,313	6,611	8,450	10,766	12,637	15,198	17,929	20,902
GENERAL CONTRACTOR'S PROFIT.....	259	390	465	538	632	684	770	836
ARCHITECTS AND ENGINEERS.....	197	306	395	471	539	655	691	820
TOTAL BUILDING COST.....	4,769	7,307	9,310	11,775	13,808	16,537	19,390	22,558

TABLE No. 10
BUILDING COST PER SQUARE FOOT OF NET RENTABLE AREA BY CHIEF COMPONENT FACTORS

<i>Component Factors</i>	<i>8 Stories</i>	<i>15 Stories</i>	<i>22 Stories</i>	<i>30 Stories</i>	<i>37 Stories</i>	<i>50 Stories</i>	<i>63 Stories</i>	<i>75 Stories</i>
EXCAVATIONS AND FOUNDATIONS.....	\$0.738	\$0.476	\$0.399	\$0.413	\$0.435	\$0.438	\$0.449	\$0.415
STRUCTURAL STEEL.....	0.717	0.798	0.869	0.952	1.009	1.151	1.351	1.726
CONCRETE FLOORS.....	0.608	0.580	0.575	0.572	0.583	0.603	0.625	0.642
PERMANENT INTERIOR PARTITIONS.....	0.224	0.233	0.256	0.274	0.286	0.321	0.356	0.386
BRICKWORK.....	0.177	0.252	0.324	0.369	0.410	0.471	0.515	0.551
EXTERIOR FINISH.....	0.397	0.497	0.515	0.531	0.517	0.508	0.506	0.515
ROOFING.....	0.060	0.057	0.048	0.040	0.037	0.036	0.032	0.030
WINDOWS AND GLAZING.....	0.191	0.183	0.195	0.201	0.209	0.221	0.230	0.239
INTERIOR FINISH AND TRIM.....	1.821	1.746	1.785	1.804	1.803	1.848	1.894	1.910
MECHANICAL EQUIPMENT.....	1.765	1.813	2.054	2.423	2.699	2.975	3.269	3.623
(a) Elevators and Elevator Fronts.....	0.614	0.651	0.868	0.926	1.104	1.245	1.408	1.656
(b) Plumbing, Drainage and Water Supply.....	0.434	0.500	0.532	0.567	0.641	0.667	0.717	0.765
(c) Electric Light and Power, Wiring, etc.....	0.269	0.305	0.323	0.352	0.364	0.384	0.402	0.419
(d) Heating and Ventilating.....	0.448	0.356	0.331	0.578	0.590	0.679	0.742	0.785
TENANTS' CHANGES.....	0.594	0.662	0.68	0.700	0.701	0.699	0.693	0.688
MISCELLANEOUS.....	0.397	0.286	0.244	0.309	0.280	0.256	0.238	0.227
PLANT AND GENERAL CONDITIONS.....	0.481	0.425	0.414	0.429	0.436	0.448	0.467	0.492
EXTRAS AND CONTINGENCIES.....	0.230	0.224	0.223	0.218	0.217	0.218	0.220	0.219
TOTAL DIRECT LABOR AND MATERIAL COST.....	8.400	8.232	8.588	9.248	9.622	10.191	10.844	11.665
TOTAL BUILDING COST.....	9.289	9.098	9.463	10.100	10.514	11.089	11.728	12.589
LAND COST (\$200 Per Sq. Ft.).....	31.553	20.172	16.467	13.695	12.335	10.863	9.798	9.041
TOTAL CARRYING CHARGES (Per Sq. Ft.).....	2.384	1.925	1.907	1.926	1.999	2.055	2.148	2.284
TOTAL INVESTMENT (Per Sq. Ft.).....	43.226	31.195	27.837	25.921	24.847	24.008	23.674	23.913
TOTAL COST ASSIGNABLE TO LAND.....	33.700	21.818	18.034	15.407	13.844	12.341	11.263	10.516
TOTAL COST ASSIGNABLE TO BUILDING.....	9.526	9.377	9.803	10.514	11.003	11.667	12.411	13.397

component factors (Table No. 10) and (3) cost per cubic foot of building volume for each of the same component factors (Table No. 11).

As income possibilities are based on net rentable area, cost per square foot of such area is more important than cost per cubic foot of building volume and will be used as the basis of comparison in most of the classifications and analyses which follow. Table No. 11, however, will repay careful analysis.

Inspection of Table No. 10 will reveal those component factors which show a tendency to rising cost with increase in building height. These include such important items as structural steel, elevators, brickwork, permanent interior partitions, heating and ventilating, plumbing and water supply, electric light and power wiring, windows and glazing. Costs per square foot of net rentable area for each of these major items are plotted in Charts No. 4 and No. 5. These charts are drawn on semi-logarithmic paper in order to make possible a fair comparison of relative variations in the various factors.

(1) *Structural Steel*

The cost of structural steel fabrication and erection is one of the largest single items in building cost. In the 8 story building it amounts to \$368,000 or 7.7% of the total direct labor and material cost of the building. In the 75 story building it accounts for \$3,093,000, or 14.8% of such direct cost. In this latter case it is exceeded only by the item, Interior Finish and Trim, which is a composite of many individual items and which makes up 16.4% of the total direct labor and material cost of our tallest building. The curve showing cost of structural steel per square foot of net rentable area (see Chart No. 4) shows a steadily rising trend as building height increases. The curve, it should be remembered, is the resultant not only of the increasing amount and greater erection cost of steel required for the higher buildings but also of the decreasing amount of net rentable area consequent upon many factors.

CHART NO. 4

Cost Per Square Foot of Net Rentable Area
Rapidly Increasing Costs

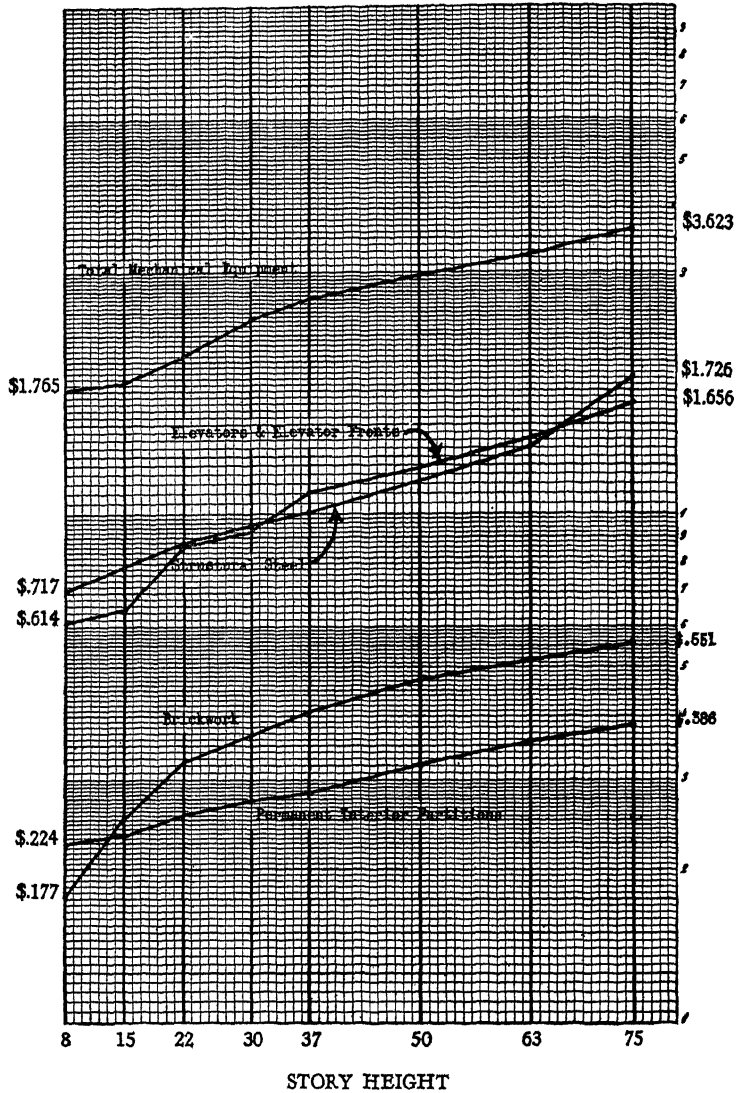


TABLE No. 11
BUILDING COST PER CUBIC FOOT BY CHIEF COMPONENT FACTORS

	8 Stories	15 Stories	22 Stories	30 Stories	37 Stories	50 Stories	63 Stories	75 Stories
EXCAVATIONS AND FOUNDATIONS.....	\$0.0424	\$0.0280	\$0.0233	\$0.0241	\$0.0254	\$0.0251	\$0.0252	\$0.0232
STRUCTURAL STEEL.....	0.0411	0.0470	0.0506	0.0556	0.0590	0.0660	0.0756	0.0965
CONCRETE FLOORS.....	0.0345	0.0342	0.0335	0.0334	0.0341	0.0345	0.0350	0.0359
PERMANENT INTERIOR PARTITIONS.....	0.0129	0.0137	0.0149	0.0160	0.0167	0.0184	0.0199	0.0216
BRICKWORK.....	0.0102	0.0148	0.0189	0.0215	0.0240	0.0270	0.0288	0.0308
EXTERIOR FINISH.....	0.0228	0.0293	0.0300	0.0310	0.0302	0.0291	0.0283	0.0288
ROOFING.....	0.0035	0.0034	0.0028	0.0024	0.0022	0.0020	0.0018	0.0017
WINDOWS AND GLAZING.....	0.0109	0.0108	0.0114	0.0117	0.0122	0.0126	0.0129	0.0134
INTERIOR FINISH.....	0.1045	0.1029	0.1040	0.1051	0.1054	0.1059	0.1060	0.1068
MECHANICAL EQUIPMENT.....	0.1012	0.1069	0.1197	0.1412	0.1579	0.1705	0.1831	0.2025
(a) Elevators and Elevator Fronts.....	0.0352	0.0384	0.0506	0.0540	0.0646	0.0714	0.0788	0.0925
(b) Plumbing and Water Supply.....	0.0249	0.0295	0.0310	0.0330	0.0375	0.0382	0.0402	0.0427
(c) Electric Light and Power, Wiring, etc.....	0.0154	0.0180	0.0188	0.0205	0.0213	0.0220	0.0225	0.0234
(d) Heating and Ventilating.....	0.0237	0.0210	0.0193	0.0337	0.0345	0.0389	0.0416	0.0439
TENANTS' CHANGES.....	0.0341	0.0390	0.0400	0.0408	0.0410	0.0400	0.0388	0.0384
MISCELLANEOUS.....	0.0228	0.0169	0.0142	0.0180	0.0164	0.0147	0.0134	0.0127
PLANT AND GENERAL CONDITIONS.....	0.0276	0.0250	0.0241	0.0250	0.0255	0.0257	0.0261	0.0275
EXTRAS AND CONTINGENCIES.....	0.0132	0.0132	0.0130	0.0127	0.0127	0.0125	0.0123	0.0123
TOTAL DIRECT LABOR AND MATERIAL COST.....	0.4821	0.4851	0.5004	0.5385	0.5627	0.5840	0.6072	0.6521
TOTAL BUILDING COST.....	0.5326	0.5361	0.5516	0.5876	0.6144	0.6354	0.6569	0.7032
LAND COST.....	1.8091	1.1886	0.9599	0.8084	0.7208	0.6224	0.5488	0.5050
TOTAL CARRYING CHARGES.....	0.1367	0.1134	0.1112	0.1120	0.1168	0.1177	0.1203	0.1276
TOTAL INVESTMENT.....	2.4784	1.8381	1.6227	1.5080	1.4520	1.3755	1.3261	1.3357
TOTAL COST ASSIGNABLE TO LAND.....	1.9322	1.2856	1.0512	0.8963	0.8090	0.7071	0.6309	0.5874
TOTAL COST ASSIGNABLE TO BUILDING.....	0.5462	0.5525	0.5714	0.6117	0.6430	0.6684	0.6952	0.7483

Why Steel
Shows Increasing
Cost

If we analyze the factor of structural steel cost, we will find it to be a composite of four outstanding items, all of which plot in a rising ratio to net rentable area. The first item, *floor steel*, naturally bears a practically constant ratio to the gross floor area which in turn, when, plotted in relation to net rentable area, shows a steadily rising trend. *Column steel*, the second item, rises more rapidly, for these upright members not only increase in height with the addition of stories but also require increase in the weight of their lower lengths and grillage footings as more floors are added. The third factor, *steel erection*, becomes more expensive in a tall building, as the derricks and plant become more complicated and more of the craftsmen's time is lost in reaching the upper levels. Finally, the cost of *windbracing*, though a small factor in comparison with the others, nevertheless increases with the height of the building.

Our Tall
Buildings
Economical in
Use of Steel

Despite all this, our structural engineering consultants reported that the weights of steel required for our tallest structures, were "surprisingly low". The following table (Table No. 12) gives, in addition to the num-

TABLE No. 12
STRUCTURAL STEEL REQUIREMENTS

<i>Building</i>	<i>Steel Tonnage Required</i>	<i>Pounds Per Cubic Foot of Building Volume</i>
8 Stories . . .	4,433 4 Tons	99 Lbs.
15 Stories . .	7,830 4 Tons	1 15 Lbs.
22 Stories . .	10,867 4 Tons	1.25 Lbs.
30 Stories . .	13,883.5 Tons	1.39 Lbs.
37 Stories . .	16,569.7 Tons	1.48 Lbs.
50 Stories . .	21,738 8 Tons	1.67 Lbs.
63 Stories . .	26,899.0 Tons	1.82 Lbs.
75 Stories . .	35,347 0 Tons	2 22 Lbs.

ber of tons of steel required for each of the buildings, the number of pounds of steel required for each cubic foot of building volume. This amount rises from about 1 pound per cubic foot in the 8 story building to 2.22 pounds per cubic foot in the 75 story building. While this rise is substantial, it is not as rapid as was expected. According to Mr. Holtzman and Mr. Coyle of Gunvald Aus Co., there are a

number of reasons why our taller structures showed an economical use of structural steel in spite of their great height. One reason was the location of the tower in the center of the plot, thus making the mass of the building approximately that of a pyramid. This form, recently made a code requirement for buildings of such heights, is of course the most stable against lateral thrust and therefore results in a saving of windbracing. A second important factor was the small column spacing and the story heights selected for our buildings; these, our consultants report, made it possible to use the most economical depth of beams. "The reasonably small column spacing," said Mr. Coyle, "not only permits the use of lighter beams without adding noticeably to the total weight of the columns, but decreases the weight of the footings materially as the sum total area of all footings remains constant with the weight of the building while the thickness of each footing diminishes with its lighter load." Finally, the setbacks were made only at the column lines rather than between the columns, which would have necessitated many heavy girders. "In a building where the lot is large enough," continued Mr. Coyle, "these can be made to coincide with the column lines and kept in scale with the building. In our study of these structures we found that at all points the effect of the larger lot and the larger building was to decrease the amount of steel per cubic foot of space developed." This is one of the results which tends to confirm our choice of a larger lot.

The noteworthy facts about the structural steel factor, however, are not that the cost of the steel frame of a building runs from approximately 8 to 15% of the total cost of the building and rises as height increases but rather that this proportion of total cost is so low and that its rate of rise is so moderate. Herein lies the possibility of any skyscraper. Without structural steel, the cost of the frame and/or supporting walls of a 50 or 75 story building would be prohibitive. One need only recur to some of the predecessors of the steel frame skyscraper. For instance, in the 10 story Montauk Building erected in Chicago in 1881 masonry pyramids practically

*Structural Steel
Makes Skyscraper
Possible*

filled the entire basement. The Monadnock Building, built in the same city a few years later, is probably the highest building ever built with burden-bearing masonry walls.⁽¹⁾ To support its sixteen stories the walls at the basement levels are nearly fifteen feet thick. In these and similar buildings this fortress-like thickness of the lower walls and the necessary paucity of window vents ruins the ground floor space, most valuable of all, while inadequate lighting and inability to shift partitions and subdivide floors to meet the varied and continually expanding needs of tenants restrict the income from the other floors. With the masonry type, therefore, the burden of the supporting frame or structure increases so rapidly with increasing height that the practicable limit is reached at a height of 15 or 16 stories. Reinforced concrete, a building material which came later even than structural steel, is a keen competitor of steel in most forms of construction and has been used in many modern buildings of moderate height. But the tallest concrete building so far erected is a 21 story office building in Dayton, Ohio, and even the most enthusiastic advocates of reinforced concrete probably would not recommend it for the modern skyscraper of 35 or 50 or 75 stories. In the present state of the science and art of construction, such towering structures are only possible because of the peculiar flexibility and economy of structural steel which provides a skeleton frame of small proportions yet of ample strength to support the "curtain wall" of stone or brick or terra cotta whose sole functions are ornamentation and protection against wind and weather.

(2) Elevator Cost

This item of Elevators and Elevator Fronts covers the whole of the equipment for passenger and freight elevators, as well as the observation elevators and escalators where these occur. As already stated, the passenger cars are multi-voltage, signal control, micro-levelling units of speeds ranging from 750 to 1000 feet per minute, with adjustments to gear the higher speed cars down to 750 feet per minute until

*Elevator Cost
Increases
Rapidly*

(1) Col. W. A. Starrett, *Skyscrapers and the Men Who Build Them*, Page 25.

such time as the New York City building code is revised to permit the greater velocities here rated. The cabs are of steel with enamel finish and the doors, both for the cabs and the shafts, are the solid, center-opening type, the ground floor doors only being of bronze. The costliness of this type of installation is indicated by the required payment of \$2,967,000 for vertical transportation in the 75 story building. This is over 14% of the total direct labor and material cost. This expenditure declines rapidly with each decline in building height, only \$315,000 being required for the 8 story building.

It is interesting to note how nearly the curve for structural steel which made the skyscraper possible, is matched by the curve for elevator equipment which made the skyscraper practicable. In the two lower buildings elevator cost is around 15% lower than steel cost but elsewhere the two curves nearly coincide. The somewhat greater irregularity of the elevator curve is due in part to the larger units of elevator equipment making more difficult a smooth adjustment of elevator service to changing heights and areas, and in part to the greater importance of the variations in net rentable areas as height increases. Thus, the 15 story building requires an extra bank of 6 elevators in addition to the 8 elevators in the 8-story building; this adds 66% to the cost of elevator equipment, while the increase in net rentable area is 56.5%. When we rise to the 22 story building, we spend an additional 63.3% for elevators whereas the rentable area increases only 22.5%, hence the more rapid rise in the curve. Between the 22 story and the 30 story building, the elevator cost rises 26.5% while rentable area increases 18.5%—a more balanced comparison recorded by a slower rise in the curve. The next interval shows a 32.4% rise in elevator cost contrasted with a 12.6% rise in area, which contrast accounts for the second jump in the curve. Above this height we reach the vertical shaft of the tower and the floor plan remains more nearly constant, with the result that the increases in elevator cost and net rentable area maintain a more uniform relationship.

In addition to increasing capital outgo as height increases, elevator facilities demand an increasing wastage of net rentable area. This factor will be discussed later in Section 8, page 65.

(3) *Brickwork*

The term brickwork as here used applies broadly to all the masonry of the exterior walls, above the dressed stone of the lower story. It includes not only face brick for walls, stock brick for walls of fire tower, and parapet-backing, corbeling and back-filling where such are required, fireproofing for exterior columns, and stock and fire brick for chimney, but also the 8" hollow tile back-up block for exterior walls, and the furring block on the inside face of exterior walls used to mask steam piping and electric conduit work on these surfaces. It does not include architectural terra cotta.

*Brickwork Cost
Rises Rapidly*

There is very little brickwork in the basement, the walls of which are concrete, or in the first and second stories where stone and glass are predominant. The third and fourth stories, though high in rentable area, have comparatively little exterior wall as the courts and wings which very materially add to the perimeter begin only above the ceiling of the fourth story. It is natural then that the ratio of brickwork to rentable area should be low in the 8 story scheme, and that it should rise very rapidly thereafter. This is shown graphically in Chart No. 4. This rapid rise of the curve continues throughout those schemes of medium height which owe their increase to the setback stories. When the tower emerges and the perimeter again becomes simplified, the curve begins to flatten out.

Of all the factors of building cost which we have plotted, the brickwork shows the greatest ratio increase from the low building to the high. This is due, however, to the factor mentioned above, namely, the small amount of brickwork in the lower stories. When we get above 37 stories, the curve continues to rise but not so rapidly as in the case of steel or elevators. The only means of vertical transportation when the brick is being laid are the derrick, the temporary hoist and

the unfinished stair. The lifting of quantities of heavy material to these increasing heights, and the time lost in getting the craftsmen to their scaffolds constitute an important charge against the cost of the higher walls, as will be seen in the rise of the curve. Actual efficiency of labor at these great heights where the laborer is working on outside scaffolds is also probably not quite so great, though some construction superintendents claim that this factor is more than offset by the fact that a very tall building would attract the best workmen who get a special thrill out of working on the most noted or most conspicuous buildings.

(4) *Plumbing and Water Supply*

This item includes all pumps, tanks, piping, standpipes, a vacuum cleaning system and all plumbing fixtures and is plotted in terms of cost per square foot of net rentable area in Chart No. 5. The slope of the curve is gradually upward, though the rate of rise is not entirely uniform.

At first sight it might be expected that the cost of these services would be in constant relation to the amount of net rentable area. This assumption, however, overlooks the fact that both the fire or standpipe system and the water supply systems are arranged in stages with tanks at intervals of approximately 170 feet. Each stage has its tank, valve and distribution system which add to cost as building height increases, though not with absolute uniformity. Allowance also must be made for the ever-present factor of cost incurred and time lost in getting materials and men to the higher floors. The number of toilet fixtures, as well as the piping and labor involved, are proportioned according to the rentable area of each structure.

*Plumbing and
Water Supply*

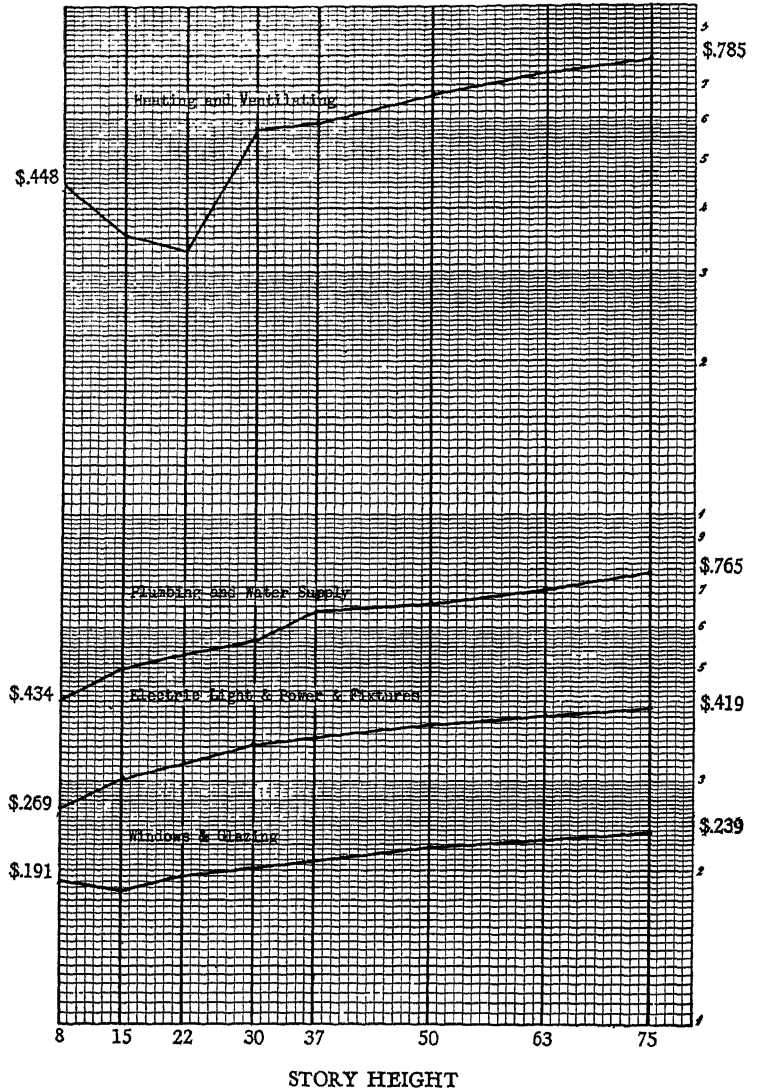
(5) *Heating and Ventilating*

Provision for steam heating is the more important of the two components of this item. However, as it is a growing practice in this section of New York City to purchase heating from outside sources, our plans did not include a steam generating plant and our operating costs were computed on the basis of steam bought from others. As a guarantee of

Heating

CHART NO. 5

Cost Per Square Foot of Net Rentable Area Gradually Increasing Costs



successful operation, should the alternative of generating steam on the premises seem desirable at any time, space for boiler plant and coal storage was provided in that portion of the basement set aside for mechanical equipment. For the same reason a chimney was provided.

The curve for Heating and Ventilating plotted in Chart No. 5 is very irregular in the lower buildings but shows a steady and gradual rise after 30 stories is reached. The steep ascent of the curve from the 22 story to the 30 story scheme is caused largely by the fact that for the buildings of 30 stories and over it was decided to change the specifications for radiators from the ordinary type to the "Recesso" type. In these taller buildings, the cost of "Recessos" was of course computed for the lower as well as the higher stories.

Mechanical ventilation, the other component of this curve, is in itself made up of separate systems or types. The toilet room ventilation is of course of the exhaust type only. As its capacity is proportioned to the number and size of the toilets, this item, if plotted alone, would show a uniform and slowly rising curve. Most of the rentable space requiring mechanical ventilation is in the basement, ground and banking floors. For such space both supply and exhaust systems would be required, and here the supply should be heated and cleaned. This factor of course raises the relative cost for the lower buildings and is chiefly responsible for the decline in cost per unit of rentable area in the 15 and 22-story buildings as compared with the 8 story structure. For the buildings of 37 stories and higher, it was deemed advisable to ventilate the elevator machine rooms with exhaust and untempered supply.

Ventilating

Thus the number and variety of the items included in this factor account for the apparent irregularity of the curve.

(6) *Electric Light and Power Wiring and Fixtures*

This item shows the same slowly increasing curve of cost per square foot of net rentable area (see Chart No. 5). The principal cause for this rise is the cost of power wiring, most of which serves the elevators. As an elevator machine room is added with each change in building height the charge for

*Electric Light
and Power
Wiring*

power wiring naturally mounts accordingly. The cost of lighting, under-floor duct work, fixtures and low tension work, is in practically constant ratio with the gross area, because public space requires wiring just as rentable area does.

However, our consultants on this phase of mechanical equipment, Mr. Otto Goldschmidt and Hatzel & Buehler, were apparently somewhat surprised that the rise in this curve was not more rapid than it actually is. They explain the matter by pointing out that the work of horizontal distribution is so much the predominating feature that the over-all electric figures are not elevated to any considerable extent by the tower work. The tower work is not excessively expensive owing to the large percentage of rentable area to total area in the higher stories. Thus for the 8 story building, the ratio of horizontal costs to all other costs is about 75%. As the building increases in height this ratio decreases but it never reaches a figure as low as 60%. The higher buildings, therefore, are not unduly penalized from the standpoint of electrical contract costs.

(7) *Total Mechanical Equipment*

This is a summation of expenditures for elevator equipment, plumbing and water supply, electric light and power wiring and fixtures, and heating and ventilating. The shape of the curve plotted in Chart No. 5 is the resultant of the various factors discussed in detail under each of the individual component items. It is interesting to note the rapid rise in the curve and the rather high percentage of the total cost of a tall office building expended in mechanical equipment. In the 75 story building, over 31% of direct labor and material cost is spent for this purpose, as compared with 21% in the 8 story building. That helps to explain why the modern office building is sometimes called a huge and complicated *machine*. In the complexity of design of such a unit, there is increasing scope for the various professions allied in its construction.

(8) *Permanent Interior Partitions*

This item includes elevator, stair, corridor and other partitions, except tenant sub-divisions, and interior column cover. The law requires 6" terra cotta partitions surrounding ventilating and plumbing shafts and all stairs with the exceptions of the fire stair. For all walls of corridors, toilets, janitor's and service closets and the various storage and service rooms required for the permanent services of the building, 4" terra cotta tile was used. The cost of the greater number of these remain in a fairly constant ratio with the floors served, regardless of building height, but the elevator and mechanical shaft partitions increase more rapidly in the higher buildings than the rentable area, since every shaft added diminishes rentable area on every floor through which it passes whereas it adds to the partition work. The added labor cost for hoisting materials is also a factor.

*Permanent
Interior
Partitions*

The curve in Chart No. 4 shows the steady and fairly rapid rise in the cost of this item per square foot of net rentable area.

(9) *Windows and Glazing*

This is another factor which shows a gradual rise as height increases. The curve is plotted in Chart No. 5.

The plate glass shop fronts on the ground floor and the varying perimeter of the buildings at the different levels have a marked influence on this curve. Where a standard base dimension is used, it is obvious that the quantity of plate glass used for show windows would be the same, regardless of building height. Hence the cost of this expensive material per unit of net rentable area would be greatest in the lowest building. In buildings over 15 stories, increasing perimeter and the declining ratio of net rentable area to building volume or to wall area cause the curve to rise with each succeeding increase in height. Time lost and cost incurred in raising men and material to the upper levels must also be considered.

Windows

6. BUILDING FACTORS SHOWING DECREASING OR IRREGULAR COSTS.

Chart No. 6 presents graphically the curve for three factors which show costs per square foot of rentable area tending to decrease (though irregularly in two cases) as additional stories are added.

(1) *Roofing*

Of these three items, Roofing is the only one which decreases steadily. The reason for this persistent decrease is not far to seek. As the area of the lot is the same for all buildings, the total area of the roof is a constant. The character and cost of the roofing, however, show some change. Quarry tile surfacing was specified for all surfaces of courts and setbacks which would be visible from rentable area above, whereas 5 ply, bonded slag roofing sufficed for the uppermost roofs in each case. Thus the 8 story building is nearly all slag roof. The roof of the 75 story structure, on the other hand, is all tile, as in this case even the tower would be architecturally developed for observation and perhaps as a roof garden. More flashing would be required for the higher buildings with their many setbacks. Labor and transportation costs would also mount somewhat, for reasons already mentioned. However, all of these factors together fall far short of compensating for the steady increase in net rentable area as more stories are added. This rate of increase of course steadily decreases. Hence the curve for cost of roofing per square foot of net rentable area steadily decreases, though at a decreasing rate of decrease on the higher levels.

*Roofing Cost
Declines*

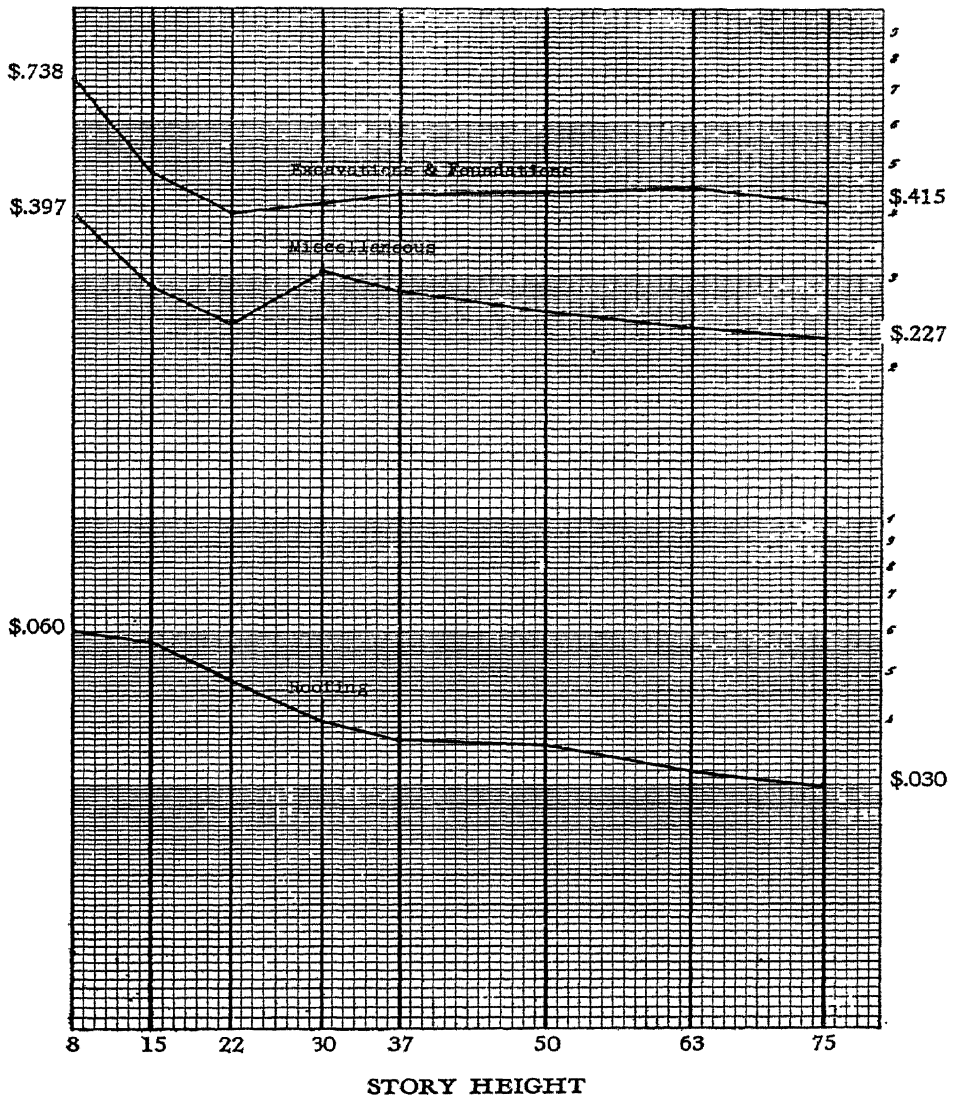
(2) *Excavations and Foundations*

This item includes cost of excavation, sheeting, column footings, machine room foundation walls, exterior foundation walls, flooring on rock and waterproofing. This site was considered to be covered with earth to a depth of ten feet and all excavation below this was taken as rock. The two lower buildings have but one basement in which the floor of the mechanical plant and boiler room was depressed six feet below the typical basement floor.

*Excavation Cost
Irregularly
Downward*

CHART NO. 6

Cost Per Square Foot of Net Rentable Area
Decreasing or Irregular Costs



The medium height schemes had in order, one-quarter, one-half, and three-quarter sub-basement, while the 63 and the 75 story structures had full sub-basement throughout the whole lot. In these also the space for mechanical plant had the floor depressed six feet. Basement walls and floor were of course considered waterproofed throughout, both integral and membrane, and ample allowance was made for drain trenches, pump pits, and column grillages.

Despite the great reduction in rock excavation for the lower buildings, this item per square foot of net rentable area is very heavy. This unit cost decreases rapidly with each substantial increase in rentable area. This accounts for the rapid decline in the curve for the second and third buildings. Later irregularities are due primarily to the changes made in the area of the basement and sub-basement.

(3) *Miscellaneous*

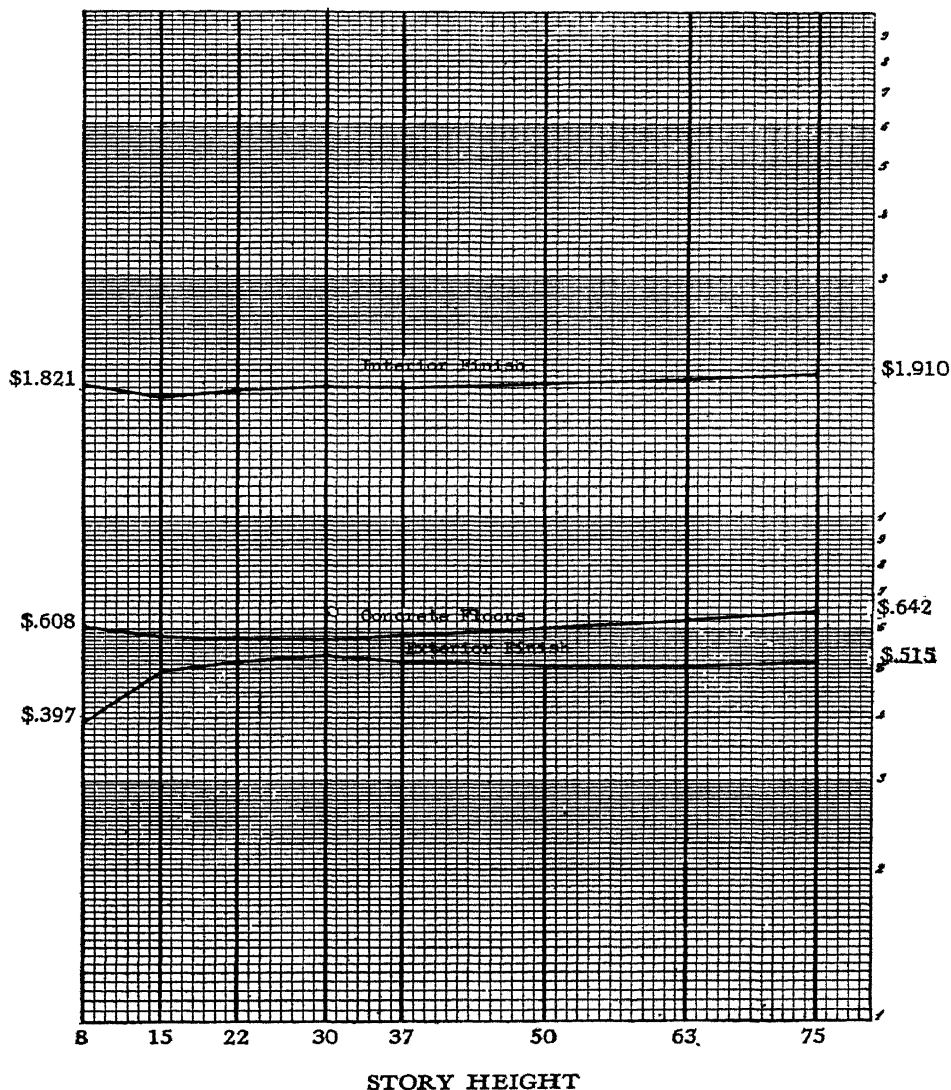
This group covers such miscellaneous small items as mail chutes, window shades, bank vaults, sidewalks and sidewalk vault-lights, and sound proofing of elevator machine rooms in the taller buildings where such a requirement would be called for. None of these items is such as to call for cost increases in proportion to building height and the curve would have shown a steady tendency to decline, had it not been for certain substantial changes in specifications in some of the higher buildings. For instance the allowance for bank vaults was greatly increased when the building reached 30 stories. It was at this point also that elevator machine room sound-proofing was considered in order. These factors account for the irregularities in the curve.

7. BUILDING FACTORS SHOWING CONSTANT COST.

In Chart No. 7 are presented graphically the cost per square foot of net rentable area of three building factors which show neither a marked upward trend nor a consistent downward tendency. We have therefore classified these items as factors of "constant cost". This means that the increase in rentable area is offset almost wholly by costs which increase at about the same rate.

CHART NO. 7

Cost Per Square Foot of Net Rentable Area
Approximately Constant Costs



(1) *Interior Finish*

Plaster, painting, marble facing for elevator lobbies, corridor wainscoting, terrazzo corridor floors, ground floor public lobby including stairs to basement shops and to banking room floors, and toilet room marble and tile are some of the many items included under this important heading. Many of these factors bear an almost constant relation to the area served on each floor. A few show a tendency to increase but their influence is offset by others which tend to decline. The group as a whole therefore is represented by a curve which is practically flat. The ground floor lobby, though less pretentious in the lower buildings, raises the ratio for the 8 story building above that for the 15 story structure. In these two lower buildings, a marble base was substituted for wainscot in all the office floor corridors. This probably accounts for the rise from the 15 story to the 22 story building. Vertical haulage and the addition of wall circulation, etc., made by the additional elevator shafts would account for slight but continual rise throughout the remainder of the curve.

(2) *Concrete Floors*

This item includes the reinforced concrete floor slab, the fireproofing of all beams and interior columns, the fill over the slab, and the cement used for finished floors of rentable area throughout. It does not include the finished floor of the ground floor elevator hall which is marble, the upper floor corridors which are terrazzo or the toilet floors which are of ceramic tile.

It will be noticed that the curve representing this factor drops from the 8 to the 15 story scheme and this drop continues in diminishing proportion until we reach the 30 story scheme. The largest floor areas relatively are, of course, the lowest. Whereas in analyzing the curve for brickwork it was remarked that the courts and wings added greatly to the perimeter and thereby ran up the cost ratio of the brickwork, the reverse is true for the concrete work. The gain in rentable area of the 15 story building over the 8 story one is 57.2% but the increase in cost of concrete work is only

49.3%, hence the drop in the curve. This method of analysis may be continued throughout. When we come to the 37 story building we find that the advantage gained in the medium height schemes is slightly outweighed by some other factor, probably by the cost of transporting men and materials to increasing heights.

(3) *Exterior Finish*

As the object throughout the whole study was to design the several buildings as closely as possible in keeping with the economic requirements for buildings of such different heights, it was decided to reduce the stone facing of the 8 story building to a 6 foot plinth. The 15 story scheme has two stories of stone, the 22 story building has three, while in all the other cases the stone facade is four stories high. Allowances for string courses and enrichment vary somewhat with the different buildings. All building and bank entrances are of bronze for the several schemes. The shop fronts and marquises are cast iron for the 8 story building and bronze for all the others. Window spandrels are of sheet copper throughout, and for parapets and all exterior trim above the stone line, architectural terra cotta is used.

This strict economy adopted for the 8 story building is well recorded in the curve. The increasing height of the stone facade is the probable explanation of the slight rise to the 30 story scheme which is the lowest on which four full stories of stone were used. Beyond this we see a very slight sinking of the curve, the terra cotta parapet copings and window spandrels and hoistage charges being the only factors on the 37, 50 and 63 story schemes to counteract the changing ratio caused by the rising rentable area. On the uppermost floors of the 75 story scheme there is a little additional detail of set-back and bay, recorded in the last rise in the curve.

8. ABSORPTION OF RENTABLE AREA BY ELEVATOR AND OTHER SERVICE FACILITIES.

In an earlier section we found that one of the factors showing a tendency to rapidly rising costs with increasing height was the outlay for elevators. This, however, is not the

only way in which the problem of vertical transportation tends to set an economic limit upon the height of buildings. For in addition to the much greater monetary outlay for adequate elevator service for the tall building is the loss of net rentable area caused by the addition of every new elevator.

*Elevators Absorb
Large Amount
of Rentable Area*

For instance, when we decide to add 12 stories to the 63 story building, we have to add an additional bank of 8 high-speed elevators. The direct monetary outlay for the installation of this group of elevators is in excess of \$700,000. In addition the amount of space used by each shaft running through each floor from basement pit to roof is enormous. In our installation, for instance, the shaft of each high-rise car takes about 90 square feet of space on every floor. This makes a total of approximately 6,740 square feet. To this must be added about 40 square feet more space per car for lobbies on each of the floors served. In the following table (Table No. 13) the total space absorbed by elevators and elevator lobbies in each of the eight buildings is presented both in number of square feet and in percentage of gross floor area.

TABLE No. 13
ABSORPTION OF FLOOR AREA BY ELEVATORS

<i>Stories</i>	<i>Gross Floor Area</i>	<i>Gross Floor Area Used by Elevators</i>	<i>Percent of Gross Floor Area Used by Elevators</i>
	<i>sq. ft.</i>	<i>sq. ft.</i>	
8	675,673	12,848	1.90%
15	1,070,778	28,426	2.66%
22	1,389,470	53,894	3.88%
30	1,647,388	79,360	4.82%
37	1,878,631	105,269	5.61%
50	2,157,859	150,007	6.96%
63	2,444,212	204,057	8.35%
75	2,689,210	262,785	9.78%

It will be noted that the wastage of rentable area due to the necessity of adequate vertical transportation increases steadily from 1.90% of total floor area in the 8 story building to 9.78% in the 75 story structure. Though it might be argued that this is relatively dark space in the central core of the building, the fact remains that it adds very materially to the cubic contents and therefore to the cost of the building, and

a glance at the floor plans will show that where the elevators have been eliminated, much of the reclaimed area has been developed and made revenue-producing. If an average net return of 50 cents per square foot be considered as reasonable for this space the 262,785 square feet of floor area absorbed by elevators in the 75 story building would mean an annual reduction in the net income of the building of \$131,392. Capitalized on a 10 per cent basis, this is equivalent to an increase in capital cost of \$1,313,920.

While the elevator installation overshadows all other factors in this respect, a similar influence is exerted by some of the other service facilities for which adequate provision must be made in the central service core of the buildings.

9. LEVEL OF CONSTRUCTION COSTS.

A minor influence in determining economic height is the level of construction costs. If such costs are relatively high due to high building material prices, high wages of building craftsmen, low labor efficiency or any other factors, the total cost of the building will constitute a larger proportion of the entire cost of the property. As building cost per unit of net rentable area tends to increase with height whereas land cost tends to decrease, the higher the ratio of building cost to total property cost, the sooner will the economic limit tend to be reached. This factor, however, is one of relatively small importance.

10. VARIATIONS IN RENTAL VALUE OF FLOORS AT VARIOUS HEIGHTS.

One serious error made by the critic who decries the skyscraper as an economic fallacy is to assume a constant or perhaps even a decreasing rate of income per square foot of net rentable area as new floors are added. It is obvious that if to increasing initial cost is added decreasing annual unit income, these two forces operating in the same direction will bring the economic height limit at a relatively low level. As a matter of fact, however, these forces work in opposite directions. To a very real extent annual unit income tends to

increase with increasing height and on a plot of adequate size, it is only after a very great height is reached that this factor making for increasing returns is counterbalanced by the forces making for increasing cost.

*Tower Space
Commands
Highest Office
Rentals*

In our buildings, for instance, competent experts would agree that by far the most desirable area is the tower space in the taller buildings. In the rental market this space will command a differential because of the following distinct advantages: (1) in layout it is approximately ideal; (2) it is above the "dirt and insect line"; (3) it is assured permanent light and air, and (4) it will command a superior outlook—in the top stories of the two or three tallest structures, a magnificent outlook. Adequate elevator service of course is, and must be, assumed. And by adequate elevator service is meant primarily very short intervals between the time of departure of the various cars. The busy tenant protests vociferously at having to wait a few seconds for a car; once in the elevator it seems to matter comparatively little how long it takes to reach his destination, provided there are not too many stops. Without adequate elevator service and despite the other factors, income per square foot would probably steadily decline as one went higher and higher into the air. This was the case before the days of the electric elevator and is still the usual thing in European countries.

*Superior Rental
Appeal of
Conspicuous
Buildings*

Another advantage possessed by the tall building is the fact that most tenants are willing to pay a slight differential for space in a conspicuous or outstanding building as compared with space in the ordinary colorless building of low or moderate height. No allowance was made for this factor in computing the incomes of our buildings, although the validity of this point is continually demonstrated by the number of rental programs which appeal to the incentive to have one's offices in a building which is outstanding in height or size or prestige-building character. Our rental consultant, however, did allow a slightly higher rate per square foot for a few floors at the top of each of the higher structures. This was done because experience shows that there are sufficient

tenants who are willing to pay more for the privilege of having their offices "at the tipmost top of the topmost peak."

Still another advantage of the tall building lies in the greater rental value per square foot of the ground floor, the basement, and probably the second, third and fourth floors. This higher unit value for these individual floors is a result of the larger populations of the taller buildings. It is a well-known real estate principle that the value of a shop location is largely dependent upon the number of the people who pass it. It is obvious, therefore, that where a building has a permanent tenancy of 12,000 to 18,000 people, as our taller buildings would be likely to have, the shops on its ground floor will be willing and able to pay higher rental, reflecting not only the passing traffic on the fronting sidewalks but also the potential business of those who pass through the corridors of the building to or from the elevators four times a day, and who in numbers equal, the population of a fair-sized city. Other things being equal, the taller the building, the larger the permanent population, the higher the rentals for the shops on the ground floor. For the same reason the basement is likely to take on increased rental value for restaurant or other shop purposes, while the second and third or the second, third and fourth floors will be in increasing demand for banking quarters. In our three tallest buildings, the second, third and fourth floors were designed for banks which would find an important market for their services among the hundreds of firms and thousands of individuals who would occupy the building. In the lower buildings, smaller amounts of space were reserved for banking quarters.

*Higher Ground
Floor Shop
Values of Tall
Buildings*

The following table (Table No. 14) reflects the composite result of all these influences making for variations in the rental value of space at different heights in our various buildings:

TABLE No. 14
GROSS RENTAL PER SQUARE FOOT OF NET
RENTABLE AREA

<i>Building</i>	<i>Average Sq. Ft. Rental for All Space</i>	<i>Average Sq. Ft. Rental for All Office Space</i>	<i>Average Sq. Ft. Rental for Ground Floor Shops</i>
8 Stories.....	\$3.54	\$2.42	\$13.24
15 Stories.....	3.46	2.77	13.80
22 Stories.....	3.54	2.96	14.48
30 Stories.....	3.59	3.11	14.95
37 Stories.....	3.62	3.22	15.45
50 Stories.....	3.75	3.36	16.98
63 Stories.....	3.82	3.48	17.60
75 Stories.....	3.86	3.54	18.23

11. VARIATIONS IN OPERATING COSTS AT VARIOUS HEIGHTS.

Annual operating expenses per square foot of net rentable area vary to some extent with the height and size of the building as the following table (Table No. 15) indicates:

TABLE No. 15
ANNUAL OPERATING EXPENSES PER SQUARE FOOT OF
NET RENTABLE AREA

<i>Building</i>	<i>Operating Expenses</i>	<i>Taxes</i>	<i>Depreciation</i>	<i>Total Expenses</i>
8 Stories....	\$0.61	\$0.93	\$0.19	\$1.73
15 Stories....	0.60	0.67	0.18	1.45
22 Stories....	0.60	0.60	0.18	1.38
30 Stories....	0.62	0.56	0.20	1.38
37 Stories ..	0.62	0.53	0.21	1.36
50 Stories....	0.63	0.52	0.22	1.37
63 Stories....	0.64	0.51	0.23	1.38
75 Stories....	0.68	0.52	0.25	1.45

Operating Costs
Trend Slowly
Upward in
Taller Buildings

The 15 story and the 22 story building show a slight decline in unit rate, presumably because the larger areas involved make possible a better organization of operating staffs and a reduction in unit cost of overhead. Thereafter, operating costs show a tendency to increase slowly, although the rate of increase apparently increases as great heights are reached. In analyzing this table, however, it is important to bear in mind that this rising trend in square foot operating cost is partly due to the declining ratio of rentable area to gross area. Another important element is the time lost in reaching the higher floors.

Taxes, it will be noted, decline steadily per unit of net rentable area until the 63 story building is reached, then rise slightly. This trend is of course due to the relative importance of the taxes upon the land.

Depreciation which is calculated on the basis of a flat percentage for the building and a higher flat percentage for building equipment shows a slight decline from the 8 story to the 15 story building and thereafter a slowly rising tendency. The changing ratio of net rentable area to building cost is the governing influence behind this trend.

III

THE ECONOMIC ARGUMENT

The Public Viewpoint

EFFICIENCY OF THE SKYSCRAPER AS AN ECONOMIC DEVICE

*Private
Interest
versus
Public
Interest*

The investigation outlined in the preceding Section has demonstrated that under the usual conditions found in the central business districts of metropolitan cities, the economic desirability of the skyscraper is beyond question from the standpoint of the private owner. It may be objected, however, that private interest may not necessarily coincide with public interest. Indeed in the case of the skyscraper it is definitely charged that the two types of interest are at variance with each other, at least to an important degree. Specifically, those who wish to curb the building of skyscrapers claim that tall buildings are an effect rather than a cause of high land values; that they destroy as much land value as they create, notably by robbing neighboring properties of light and air and by depressing values of property at some distance from the "high building nuclei"; and that they present the public with expensive and difficult problems to solve in the provision of the necessary city utilities.

*The
Skyscraper
an Economic
Device from
Public
Viewpoint*

In the opinion of the present writers, the skyscraper has demonstrated its efficiency not only from the private, but also from the public, point of view. So far from enabling the private owner to derive an undue profit at the expense of his neighbors and the public generally, the skyscraper, under such reasonable regulation as will be discussed in later sections of this Report, provides a fair profit to its owner because it performs efficiently an important *public service*. The

product of American conditions and of American ingenuity, it is one of the most efficient economic tools that has ever been devised. Judged by its contribution to the development of our commercial civilization, it has every reason, in our opinion, to rank with the telephone and the automobile, though perhaps somewhat lower than the steam engine and the electric dynamo. The reasons for this belief will be outlined in the succeeding paragraphs which will also consider the specific criticisms just outlined.

In the first place, this modern invention is a highly complex mechanism which furnishes a commodity of such distinctive merit that the public are willing to pay dearly for it. That commodity is office space. Its manufacture is the most complicated and the most difficult of all manufacturing processes known to man. It never becomes a standardized process, performed repetitively within the four walls of the same factory; always it involves an individualized product, made to order on the spot to suit the conditions of a given location and the requirements of an individual owner. Before the manufacturing process can begin, the technical skill of a half dozen different professions must be drawn upon—architects must prepare designs and draw plans, structural steel and foundation engineers must design the steel skeletons and foundations in accordance with the requirements of the design, other engineers must design heating, lighting, plumbing and ventilation in accordance with the same architectural requirements. Then begins the dramatic work of the manufacturer, in this case called the builder, whose burden of management is heavier than that of any other manufacturer, involving as it does the coordination in time and place of a score or more of different trades and hundreds of different types of materials drawn from all over the world, and the performance of tasks of skill and daring under very distinct limitations of space and time. The resulting skyscraper is not only a machine but a machine of machines, one of the most complicated and most expensive products of the handiwork of man.

*A Complicated
Machine*

Under modern business management, such a structure

*Superior Quality
of Product*

provides a service consisting of the daily use of office space which in arrangement and layout, in heating, plumbing, ventilating and other service facilities, in accessibility to tenant and customer and the means of supplying routine daily needs, in illumination whether natural or artificial, in freedom from dust and dirt and noise, in cleanliness, in comfort and luxury of all appointments, in outlook towards sky and horizon, in freedom of risk to life and limb, in character of associations, in prestige-building character, and in prompt and efficient catering to the tenant's daily needs is far superior, taken as a whole, to any competitive product that can be put upon the market. Many of the superior features of the skyscraper's service obviously come from the fact that the product is manufactured on a large scale production basis. For instance, the tall structure can afford to give an elevator service, sanitary facilities, a ventilating and air conditioning service, comfortable and luxurious appointments, etc., which would be too costly for the low building. Further, because of its large scale operations, it can afford a specialized, scientifically trained building management service in place of the janitor service to which the small low building is largely limited. The superior light and air of the upper stories at least, the more inspiring outlook, and the tenancy prestige are due solely to the factor of increased height. No matter what the cause, it is the superior service, the greater tenant satisfaction, which explains why the user of office space is willing to pay the price he does pay for the product of the skyscraper. *Other things being equal*, he will take skyscraper space in preference to low building space and is even willing to pay *on the average* a higher price than for similar space in low buildings. This differential in market favor should be sufficient proof, if any other were needed, that the skyscraper is an efficient economic device, that it contributes not only to private profit but to public service as well.

In the second place, this modern invention makes possible or at least practicable that high degree of regional specialization and concentration which modern commerce seems to

require for the utmost efficiency. The commercial city is itself of course an illustration of the results of this driving demand for the efficiency which comes with territorial division of labor. Professor R. M. Haig of Columbia University, in his attempt to discover an explanation of the present world pattern of population, first posed for himself the abstract question "what kind of a pattern would result if one were deliberately to plan a world for economic efficiency", and found the answer in a world very much like the present with great concentrations of populations in urban areas tending ever to grow greater.⁽¹⁾ Says Prof. Haig:

*Facilitates
Regional
Specialization*

"This suggests, then, that the kind of a pattern which would give the greatest economic efficiency under the assumptions stated is one which makes maximum use of territorial specialization within the limits set by the available means of transportation. The most favored spots are those from which the richest resources can be tapped with the lowest transportation costs. At such points would develop the great cities. Smaller urban centers would be expected to appear at less favorable points, to the extent that in accordance with the law of diminishing returns, the degree of intensity of utilization raised costs and thus forced a resort to the poorer resources."

Later⁽²⁾ he summarized his discussion of the factors effecting the general world pattern of population distribution as indicating "that the urban areas are apparently the most economical points at which to supply people with the varied assortments of goods and services in effective demand at the present state of the world's development; that, assuming a given state of the arts and a given distribution of natural resources, the relative importance of rival urban areas is determined fundamentally by relative transportation advantages; and that the entire 'foot-free' population (all persons not required to man the natural resources, the 'portability-producing' industries, the 'supplementary' industries, the transportation system, and the necessary services to supply such persons with their consumption assortments) is tending to locate in urban areas."

*The Commercial
City*

(1) "Towards an Understanding of the Metropolis", *Quarterly Journal of Economics*, February, 1926, page 186.

(2) *Op. Cit.*, May, 1926, page 402.

In still another place,⁽¹⁾ Prof. Haig states that "instead of explaining why so large a portion of the population is found in urban areas, one must give reasons why that portion is not greater. In the lower cost of supplying consumption goods at these convenient assembly points is found, then, a positive and, in the opinion of the writer, a very powerful force tending constantly toward the concentration of the entire 'foot-free' population in urban areas. To justify locating a person elsewhere some advantage in production or in consumption must be obtainable sufficient to counterbalance this fundamental advantage of concentration".

Each city will have its own special advantages and its growth will be dependent on the strength of these attractions and the competition of other urban areas. In the case of New York City the factors which will make for a continuing increase in population and business activity have been enumerated by the Committee on the Regional Plan of New York and Its Environs as (1) the unique extent of the undeveloped natural opportunities of the Port of New York to serve the needs of any conceivable growth of industry and population, together with the impetus toward further expansion which already exists because of unparalleled concentration of transportation facilities; (2) the existing concentration of great financial institutions and commercial and industrial activities, with their power to expand further and thereby attract additional business and industry; and (3) the extent and variety of business and cultural opportunities incident to the high degree of concentration of wealth and commerce and providing attractions for increased migration from smaller districts and rural areas. More and more, New York will grow to be the great business, financial and cultural centre of the world—the great international clearing house in matters of commerce and finance, the great international magnet for those who seek social and cultural opportunities. This is a tremendous tribute to the value of concentration.

(1) Op. Cit., February, 1926, page 188.

Not only are the advantages of territorial specialization and concentration responsible for our great cities but the economic pattern of each of these cities is in turn determined by these same forces. While at first sight the distribution of economic activities in most cities may seem to be largely without rhyme or reason, closer study indicates that powerful economic forces are at work which ultimately wipe out the apparent anomalies temporarily resulting from the constant process of adjustment to changing conditions. Stated briefly, there is going on a constant struggle between the various urban economic activities for the vantage points of location. The keenest competition of course is for the so-called "center of the city" which in Prof. R. T. Ely's words⁽¹⁾ is "merely the point of greatest concentration of people in a market". At any given time, the pattern of the city reveals a more or less orderly arrangement of activities radiating from the city's center, the sequence depending on the ability of the various activities to bid for the advantages of convenience, time saving and labor saving involved in accessibility to the center. As competition for advantageous sites becomes keener with the growth of population and of business, the economically weaker types of industries or services are forced out to less accessible and lower-priced locations, an order of precedence amongst such activities being worked out by competitive bids based on their relative ability to utilize profitably the most accessible sites.

*Specialized
Districts*

This process tends to result in a series of specialized districts which become more clearly defined as the city grows. Thus in New York City we find the leading financial section centering around Wall Street with a secondary financial and office building center around the Grand Central Terminal, a garment manufacturing district west of Broadway above the Pennsylvania Railroad Terminal and a high-grade retail shopping district on Fifth Avenue, while legal offices tend to locate not far from City Hall, automobile concerns around Columbus Circle, architects and building concerns near 42nd

(1) *Characteristics and Classifications of Land*, page 143.

Street, and silk factors and wholesalers near 34th Street on the East Side. A similar trend is found in all great cities. Business seems to do better "wedged against its competitor than off by itself". Like businesses flock together because it pays them to do so.

An admirable illustration of the advantage of such specialization is given by Prof. Haig in his discussion of the factors responsible for New York's financial district:⁽¹⁾

Causes of
Concentration
in Wall Street
District

"The highest values in the city are in the Wall Street and the 42nd Street sections. The Wall Street district, filled with high buildings, is dedicated to 'finance'. The 42nd Street section is primarily a retail merchandising section, altho it has recently developed considerable importance as a miscellaneous office center. 'Finance', as here used, includes the exchanges, the banks, the insurance offices, as well as various professional groups, such as lawyers and accountants. Largely through the control of loanable funds, there is centralized here the function of coordinating the business activities of a very wide area.

"The exercise of this managerial function of coordination and control is at first glance singularly independent of transportation. It does not require the transfer of huge quantities of materials. It deals almost exclusively with information. What is all-important is transportation of intelligence. The mail, the cable, the telegraph, and the telephone bring in its raw material and carry out its finished product. Internally easy contact of man with man is essential. The telephone is prodigally used, of course, but the personal conference remains, after all, the method by which most of the important work is done. Conferences with corporation officers, with bankers, with lawyers and accountants, with partners, with fellow directors, fill the day. The work is facilitated when the time of the men whose time is most valuable is conserved. The district must be conveniently accessible and must be at the heart of the system of communication. *It must be arranged so as to give the greatest possible ease of contact among men whose presence is desired in arriving at decisions.* ⁽²⁾ The financial district is in effect one big structure; the streets, practically cleared of all except pedestrian traffic, are little more than corridors and air-shafts. The corner of Wall and Broad on a busy morning is much more quiet than many a suburban corner. *The geometrical proposition that the contents of two spheres are to each other as the cubes of their diameters has sent skyscrapers up into the air.* ⁽²⁾

The Skyscraper
a Product of
Conditions

"The closely interrelated and interdependent group in Wall Street find their functions sufficiently facilitated by a central lo-

(1) Quarterly Journal of Economics, May, 1926, pages 426-428.

(2) Italics ours.

cation to make it worth their while to outbid all others for the spot they want. It may be observed that this group of activities in the financial district is concerned, for the most part, with matters of great import, not with petty transactions. A decision as to whether the Kingdom of Norway shall be loaned \$25,000,000 of American capital and whether the rate shall be five or six per cent, is obviously more important than a decision as to whether a neighborhood haberdasher shall be granted a loan of \$250 and at what interest rate. One transaction may require no more physical space than the other and about the same amount of time, but the Norway decision will be made by a man whose time may be worth more per hour than the branch-bank manager earns in a month. A change to a more convenient location, which would save the large banker one hour per day, might justify an increase in site rental of \$30,000 per year (300 hours at \$100 per hour). A similar change in the case of the branch-bank manager would justify an additional site rental of only \$300 (300 hours at \$1 per hour)."

As Prof. Haig indicates, this tendency to concentrate not only business as a whole in a limited area but also businesses of certain kinds in certain specialized areas has been made possible, or at least immensely facilitated, by the skyscraper. It has enabled us to put great masses of concentrated business population on comparatively small areas. The idea is developed and effectively illustrated in the following extract from an address by Harvey Wiley Corbett before the annual meeting of the United States Chamber of Commerce, May, 1927:⁽¹⁾

*How the
Skyscraper Aids*

"Along with that (increased) scale of production has gone the development of business buildings, whose function is simply to facilitate business. They are just practical machines for carrying on this very important work. That development has kept pace with business. It has made business possible, and it is only through the concentration in comparatively small areas of large numbers of business people that we can conduct our affairs at all.

"In my opinion the reason that America today is leading the world in commerce is because her business men have had the sense and the foresight to carry on their affairs in limited, concentrated areas where they can get at each other, where they can talk things over.

"You know that every business transaction is settled by personal contact, in spite of the telephone and the telegraph and all the

(1) Reprinted by the Chamber in special bulletin on Economic Height of Buildings, pages 9-11.

other means of communication. You finally have to get the man into your office, have him take out his fountain pen and sign on the dotted line. It can not be done any other way

"You know that America differs from Europe in this one respect, in regard to business locations.⁽¹⁾ In Europe you never can find, in any city, a zone in which certain things are done. The old theory was that if a man had a drygoods store he did not want any other drygoods man in his neighborhood. That does not apply in America. The drygoods man wants another drygoods store across the street. The theatre man wants another theatre in the immediate neighborhood. *We have found, as a matter of business efficiency, that the more men with the same kind of business that can be brought together in a given zone, the better the business is for all of them.* That is a very interesting cooperative community idea, and you will find in practically every city in the United States business zones where the office work of the city is done, where more buildings pile up alongside those already there. That is not a question of exploiting the property. It is not a question of getting a maximum return out of a given piece of real estate. That may have been the origin of the skyscraper in the first instance, but exploitation is not permanent economy, and we would not have our skyscraper zones if they had not proved to be of real value from the point of business efficiency.

"Take the district in which I have my office in New York. All the building world is within two or three squares of my office, on 42nd street. I can call on the telephone any architect, building supply material man, or any other man in the building field, and in 15 minutes time, on foot, I can be in his office, or he can be in mine.

"Now, let us imagine that we took that district around 42nd Street and flattened it out, as Mr. Curran says, to seven or eight stories. I think he would flatten it down to two if he could, but we will assume seven or eight. What would it mean? It would mean that that quantity of business had been spread out over a mile or a mile and a half; that the possibilities of business contacts would be limited by just that increased distance, and that the length of time required to do the business which we can do in one day would spread out to a week or more.

"You only have to go to London and see just exactly what I mean by that illustration. In the City of London, which is probably a four story average over the city, and in which there are no skyscrapers and no concentrated business zones, if you attempt to make three business appointments in a day, you will do very well, because they will be scattered over every portion of the city,

London
versus
New York

(1) This statement is somewhat exaggerated. European cities also show a tendency to develop specialized districts but the tendency has not gone as far as in some of our large cities.—Editors.

and you will add to the congestion of the street by attempting to take a taxi or a bus or a motor or the subway in order to carry on your business affairs."

The ultimate point to which the skyscraper can go in fostering that geographical specialization and concentration which modern business requires for the utmost efficiency is found in the specialized building and the multiple purpose building. Many office buildings are now devoted to a specialized use, either the housing of a single firm or group of related firms or else the provision of offices for a great number of competing firms in the same or allied industries such as doctors and dentists in a Medical Arts building or architects, contractors and building supply firms in an Architects or Engineers building. Such a building merely intensifies the advantages of convenience and time-saving referred to above by Mr. Corbett and will have its supreme illustration in the 100 story structure now being designed to house the 30,000 employees of the Metropolitan Life Insurance Company. Perhaps of greater importance, certainly for the future, is the composite or multiple purpose building. Practically all large office buildings are at least dual in purpose—that is, the lower floors are used for shops and the upper floors for offices. But the modern tendency is to go beyond this and to provide in a single building practically every service which the tenants normally require. In many buildings, the demand for offices, for shops, for theatres and other forms of amusement, for medical, legal and professional services, for restaurant facilities, for gymnastic exercise and for club contacts is now reasonably taken care of so that the tenant, without leaving the building, may have immediate recourse to every possible need except housing accommodations. The next advance—and already a few buildings have pioneered the way—is to add residential accommodations to the bewildering assortment of facilities already provided. In this step we will merely return to "the old-fashioned idea of the living quarters above the shop", not of course in the old way but by means of a multiple purpose skyscraper which will devote its ground floors to shops, its next 30 to 40 stories to offices and its upper

*Specialized
Buildings*

30 or 40 stories to residential and social use. Then indeed we will have a self-contained city, accommodating many thousand people, carrying on practically all their activities in a single structure erected on an entire city block—in Col. W. A. Starrett's phrase,⁽¹⁾ "probably the most profoundly efficient and adequate conception of gigantic size ever created by man". This vision of efficiency is made possible solely by the skyscraper—and the vision is fast becoming a reality.

*Alleged
Disadvantages
from Public
Viewpoint*

Enough has been said probably to prove that the skyscraper is an efficient economic device. It is claimed, however, that however efficient in itself, it confronts the city with a number of expensive and difficult problems to solve. In particular, some critics loosely assert that it leads to an ever-mounting cost of city and utility services—electricity, heat, water, sewerage, police and fire protection, street and sidewalk capacity, rapid transit and other transportation facilities. This higher cost, it is claimed, is thrown upon all property owners and the community in general in the form of higher taxes.

*Skyscraper
Does Not Cause
Higher Cost for
City Services*

The charge will not bear analysis. Growth in population and business activity will obviously bring a rising cost for such community services but careful examination of the facts will indicate that the cost of supplying practically all, if not all, of the above utilities will be lower in a centralized, high building city than in a decentralized, low building city of equal population. Large scale production, here as elsewhere, leads to economies. As Mr. Ernest P. Goodrich admits, ⁽²⁾ the cost of installing telephone, telegraph, electric light and power cables, as well as sewers and water mains, will be lower in the high building city because it is "relatively somewhat cheaper" to install large cables, sewers or mains than small ones. "Vacant properties and those improved with low buildings cost the municipality more in proportion than those which have high buildings, because of extra length of distribution mains of all kinds". With regard to sewers, Mr.

(1) *Nation's Business*, April, 1929, page 158.

(2) Report of Regional Plan of New York and Its Environs on Land Values, Engineering Series, Monograph No. 3, page 37.

Herman H. Smith, Assistant Chief Engineer, Board of Estimate and Apportionment, New York City, tells us that the cost of sewers will not be increased by tall buildings,—rather that so long as the mains are big enough to take care of heavy rains they would be able to take care of tall office buildings. The Regional Plan's report on Land Values⁽¹⁾ points out that tall buildings require special fire-fighting equipment on the part of the Fire Department, a high pressure water supply system in the skyscraper district and a higher class of building inspection. This is true, as Section V of this Report will make clear; but in the first place such increased cost is insignificant in relation to the property values involved and is probably more than counterbalanced by the compact nature of the skyscraper area to be protected, by the superior fireproof character and fire-fighting equipment and personnel of the modern skyscraper, and by the service performed by the skyscraper in checking conflagrations.

This point of view is approved by a leading New York authority in fire prevention work who points out (1) that the skyscraper city would have high pressure fire service mains, fire tower stairways and practically 100% fireproof construction as contrasted with the smaller water mains, the absence of fire towers, the wood floor and trim and the non-fireproof character of much of the decentralized city; and (2) that the former would have fewer fire houses, fewer men, and fewer (though more costly) pumpers or fire engines than would be required to give adequate service in the scattered, low building city. The centralized fire houses, moreover, would mean shorter runs for the engines and therefore quicker attack which in turn would mean smaller fires and reduced fire loss and water damage. He also points out that the high pressure fire service mains were installed in New York City from 1906 to 1916 prior to the erection of many high buildings. The protection which the skyscraper gives against the conflagration hazard is also a public economy whose importance should not be underestimated. As F. W. Fitzpatrick states,

(1) Op. Cit., page 37.

"you cannot get up a conflagration in even second class fire-retarding buildings."⁽¹⁾

*Transportation
Facilities*

The relative cost of supplying the various traffic facilities in centralized and decentralized cities would seem to be a more debatable question because it is more difficult to disentangle the effects on traffic volume of mere growth in population and business on the one hand and of increased building height on the other hand. This traffic problem is a highly complicated one and must be postponed for detailed discussion until a later section of this Report. We may here express the conviction, however, that with traffic as with water distribution, the centralized city consisting of a compact group of buildings, say, of 50 or 70 stories in height would be more economical than a decentralized city where the same population endeavored to do the same volume of business in 10 or 15 story buildings scattered over an area four or more times as large. The saving through reduction in number and area of streets would be great, even allowing for the narrower width of street required and the lower cost of land in the decentralized city. For instance, if a reduction in building height should result in spreading the city over an area four times as large as formerly, 3.6 times the former mileage of streets would be required. Saving in cost of sidewalks would be considerable not only because of this reduction in number and length of streets but also because of such developments as the arcaded sidewalk provided within the building line. In regard to rapid transit facilities, it is fair to assume that when a city, whether centralized or decentralized, attains much beyond a population of 1,000,000, subways will be necessary to provide economical rapid transit. When this stage has been reached, the centralized city will normally find it somewhat easier to provide such facilities than will the decentralized city, though of course differences in topography, natural barriers, subsoil, city layout, etc., make it difficult to generalize for all cases. Individual subway arteries will undoubtedly cost more in

(1) *Studies on Building Height Limitations in Large Cities* (Published by the Chicago Real Estate Board, 1923), page 181.

absolute dollars in the high building city because of the greater traffic capacity provided, but relatively fewer or shorter arteries should be required. For instance, a double-deck subway or a four-track subway which may serve a compact area adequately, will cost less, other things being equal, than two two-track subways or one two-track subway of twice the length, which would probably be required to serve an equal population spread over an area three or four times as large.⁽¹⁾ The saving will not be as great in the "cut and cover" type of high level subway construction which is standard in New York City as in the "tunnel" type which is possible in other cities, and may not be as great as in most cases of large-scale production because the extra columns and heavier steel required in the broader arch of the larger tube offset to some extent the reduction in cost of outer walls and other economies. Subway engineers, however, report that additional special gains arise from (1) lower costs in connection with replacing mains and cables for the various utilities and the highly expensive operation of underpinning of buildings, skyscrapers usually having their foundations already resting on solid rock, and (2) the tendency in highly concentrated skyscraper sections to have subway terminals in the important buildings, the cost of such expensive terminals being borne by the buildings themselves. An important economy in favor of the centralized city would accrue in the actual operation of the subway, because the concentration of population should make possible the utilization of such rapid transit facilities to a higher percentage of their maximum capacity at all times. Exceptions to the above general statement of principle may occur, particularly where initial construction costs may be abnormally high in tall building cities because of very narrow streets or serious interference with heavy traffic, but on the whole, to use the words of one subway engineer, "the centralized city would seem to have the edge".

Incidentally, the point may be made here that even if high buildings should cause a relative increase in the cost of these

(1) Experience seems to indicate a fairly constant ratio between number of miles of running track and number of miles of track in the delivery area.

various community services, the burden would be borne largely by these same buildings. In New York City, for instance, 70 per cent of the total cost of running the city falls upon real property—a proportion which many observers believe to be unfairly high. If the skyscraper critics are right, increased rapid transit facilities mean higher values at the centre in the skyscraper district and lower values elsewhere. The skyscrapers, therefore, would presumably bear the vast bulk of the increased burden.

*Effect on
Land Values*

Finally this whole question of the effect of tall buildings upon land values demands consideration. Is it really true, as alleged, that the high building is a symptom rather than a cause of value, and that it actually destroys more value than it creates? If the findings already outlined in this Report be correct, the answer to this question must be an emphatic no. If it be true, as we believe we have demonstrated, that in certain strategic sections of our leading cities the skyscraper is the only development of a plot that will give a fair return upon the required investment and that it is an efficient economic device from both the public and the private viewpoints, then it must follow that it is a creator rather than a destroyer of land values. If it represents the most efficient method of developing our central business districts, then the total land value of the city will be increased rather than decreased. It is not simply a matter of increasing values in certain high building sections and decreasing them by as great or an even greater amount elsewhere. Inefficient utilization of land means a definite public loss as well as a private loss. If building height limitation means an inadequate return from urban sites, then values which in the final analysis are based upon anticipated income will decrease. If it means an inadequate or inefficient utilization of those particular sites, this decrease will not be fully compensated by higher values elsewhere. The city's greatest good, whether measured in the dollar value of all the land within its bounds or by some more intangible measure of civic benefit, demands that the most efficient use of all its land should be made. That criterion, as we have

seen, calls for tall buildings, not necessarily everywhere but at least in certain limited areas. In saying this, we do not forget to bring into our conception of "most efficient development" due regard for the reasonable requirements of sunlight, air, safety and accessibility to be discussed in later sections of this Report.

High buildings must of course be built in the right locations. Their function is performed in those urban centers where there is the highest degree of accessibility and is to serve economic activities which require and can therefore afford to pay for this maximum degree of accessibility. There is this of truth in the claim that they are a symptom of high land values—they do reflect the existence of other forces which create values, such as the convergence of transit facilities. Without the existence or the early probability of a concentrated population and the facilities for great accessibility, they would not exist. They would not create high land value in a desert. On the other hand, without them the high values which they create at such points of traffic convergence would not exist. If buildings in the Wall Street district or the Grand Central Zone of New York City were limited to a height of 10 or 20 stories, land values in those centers would only be a fraction of what they are at present. It is only because advantageous plots in these areas can be developed intensively with magnificent modern buildings of great height that they command such huge prices in the market. In other words, tall buildings are a cause, and not merely a symptom, of high land values.

*Symptom or
Cause?*

It has been said that the decision of prominent real estate operators not to erect skyscraper office buildings on certain sites between 52nd and 57th Streets on Fifth Avenue in New York City brings into question the economic value of tall buildings in general.⁽¹⁾ This decision indicates nothing of the kind. It proves merely that this particular location is a high grade shopping area and that for the present at least there is

*A
Non-Sequitur*

(1) Regional Plan of New York and Its Environs, Report on Land Values, page 38.

not sufficient demand in the neighborhood for large office buildings. If there has been one point which we have tried to emphasize, it is that tall buildings should not be built everywhere—rather that buildings of very great height are normally justified only on certain strategic plots in the central business districts of our leading cities. Each urban site presents an individual problem. It should be developed to its maximum efficiency for its appropriate use, taking all the pertinent circumstances into consideration.

*Help to
Stabilize
Values*

Not only do tall buildings create values, they also tend to stabilize such values. In a skyscraper district, the aggregate investment is likely to be so great that it acts as a powerful anchor against the tendency to shift to other locations. That does not mean that shifting and resultant decline in values may not take place—indeed if transportation facilities have not kept pace with traffic demands, the congestion evil may act as a propelling force encouraging business to shift to newer and less congested areas. Moreover, while as indicated above a skyscraper usually reflects the pre-existence of accessibility and population concentration, it may sometimes be built in a relatively undeveloped location in anticipation of such favoring factors. In such cases, the tall building creates values in the new location but is likely to cause a decline in such values in the older districts. The point has been forcibly stated by Col. W. A. Starrett in the following extract from his intensely interesting book on "Skyscrapers and the Men Who Build Them":⁽¹⁾

"One singular and significant fact of skyscraper construction here stands out, and that is its power fairly to move centers of cities. Under the old order, the cross roads, vast traffic streams and dense population knew no law but itself, and intensive building submissively remained where density had ordained it should stay. But now it is different. Great structures can actually beckon the trends of population and traffic, and in a measure can compel the shifting of economic centres of gravity. Witness the growth of Cleveland as it shot out Euclid Avenue, abandoning the century-old focus at the Square, and creating in a decade substantially a new city where only yesterday were residences."

(1) page 59.

Such shifting would be enormously easier, however, if no tall buildings existed in the older districts. A skyscraper, because of the enormous monetary stake represented by itself and the neighboring skyscrapers which it attracts, acts as a powerful force conserving and stabilizing property values.

It is said that buildings of great height depreciate other buildings, and therefore values, on adjacent sites, by withdrawing tenants from them. "The higher the building the smaller is the area of land that is required to meet a given demand for floor space. Consequently the areas of blighted or deteriorated buildings are greater in proportion as vertical growth takes the place of horizontal growth."⁽¹⁾ This is the sad lament of every producer who sees his competitor throwing a better and more up-to-date commodity upon the market—"My competitors are withdrawing customers from me, my factory will be left unoccupied and blighted, my laborers will be thrown out of work, etc." Progress always involves certain wastes, certain pains of readjustment but the American people at least believe that it is worth while. They are prepared to stand the costs of competition and of progress because it results in the long run, in their opinion, to the greatest good of the greatest number. Cities are growing organisms; they are dynamic; merely because they are growing they will reveal at any given time individual buildings and areas which have suffered in the inevitable march of progress and which must readjust themselves to changed conditions. However, it should be noted that this adverse competitive effect is partly or wholly offset by the favorable effect of a new skyscraper upon values in the immediate neighborhood. A rise in values of adjoining plots almost always follows the erection of a new modern skyscraper in a suitable location. Old, semi-obsolete buildings may suffer initially but in the long run, either they or the more up-to-date structures which replace them, show increased values because the adjoining skyscraper was erected. As already stated, in America like businesses attract each other. Hence, skyscrapers, the purveyors

*Blighted
Neighborhoods*

(1) Regional Plan of New York and Its Environs, Report on Land Values, page 38.

of office space, do better side by side. Each helps the other. A tall building standing alone always has to justify itself in the eyes of the real estate operator. If conditions are right and the building is an outstanding one, it may prove to be a successful pioneer but a certain risk is involved. This general truth that neighboring buildings benefit each other is not invalidated by the fact that at times a temporary over-supply of office space may exist resulting in severe competition.

It is also said that skyscrapers depreciate values by restricting available sunlight and air both for themselves and for their neighbors. There are cases where values have been depressed to some extent in this way; but, as the following Section will show, the unfavorable effect on the few lower floors of the skyscraper itself is much more than offset by the improved light and air in its upper stories and under reasonable setback restrictions the influence on adjoining buildings may be reduced to insignificance.

IV

THE PUBLIC HEALTH ARGUMENT

LIGHT, AIR AND NOISE

One of the major indictments of the tall building is based on the deleterious effect of alleged light and air restrictions upon public health. Tall buildings, it is said, cut off sunlight from the street level and from the lower floors of adjoining buildings and interfere with the free circulation of fresh air; the surface of the pavement and the lower stretches of the atmosphere are being constantly polluted; sunlight and drying are needed to sterilize them; if they are not sterilized, the people who throng the streets and live in the offices are likely to suffer infections, principally of the respiratory tract. The crowds in the street cars and subways, and in lesser measure, on the streets, increased by excessive congestion through high buildings, is a factor in the spread of some form of contagion. "It may be true, as some medical bacteriologists claim, that crowd exposure tends to build up an acquired immunity against certain diseases so that to some extent Nature protects herself, but the fact remains that, on the whole, crowding speeds up and increases the transmission of disease."⁽¹⁾

*The Argument
Stated*

Not only is sunlight decreased but also the air is bad because the gases, smoke and soot from automobiles, railroad engines, etc., do not get into the open and diffuse. Finally the lack of sunlight and the continuous use of artificial light which is necessary in many offices is injurious to the eyes and

(1) George C. Whipple, Professor of Sanitary Engineering, Harvard University, in Transactions of American Society of Civil Engineers, Vol. 88 (1925), page 608.

nerves and constitutes a detriment to physical and mental efficiency.

*Upper Floors of
Tall Buildings
Enjoy Ideal
Conditions*

In examining this argument it is first necessary to point out that insofar as office interiors are concerned, the conditions complained of apply, if at all, only to a few of the lower floors of tall buildings. Certainly the upper floors of a modern skyscraper enjoy to the maximum extent the benefits of abundant sunlight, fresh air and a cheerful outlook.⁽¹⁾ The higher the floor, the greater and the more permanent are such benefits. That is why our rental consultants insisted that tenants would be willing to pay higher rentals for the setback floors of our 63 and 75 story buildings—they are assured in perpetuity of a flood of sunshine and fresh air and a magnificent outlook. Abundance of sunlight is further assured by the treatment of windows in the modern skyscraper. In the heavy masonry construction of forty years ago the window was a mere slit in a very thick wall. With the development of the steel frame building, windows have steadily increased in size and the next step may easily be the enlargement of the window from an opening in the wall to the wall itself. In other words, there are architects today, notably Mr. William Orr Ludlow of New York City, who contemplate skyscrapers in which masonry or brick will give place to sheets of glass—or even of glass through which the ultra-violet radiations of the sun may pass, thus permitting sunlight to exercise its full therapeutic and aesthetic effects.

If we grant that offices on the lower 5 or 6 floors would not have the advantages possessed by the upper floors, it does not follow that conditions therein would constitute a menace to public health. On the contrary it is possible, and becoming increasingly common, to provide artificial illumination and artificial methods of ventilation and atmospheric control

(1) "Suppose every building on Fifth Avenue were reduced to five stories—the automobile fumes, which would be equally prevalent then as now, would pervade every room the entire length of the Avenue; whereas now above the fifth floor an amount of fresh air is available, above the tenth floor a great deal of fresh air is available, and above the twentieth story we are really sitting in the lower Adirondack heights of fresh air and purity."—Alfred C. Bossom, *New York Times*, November 28, 1928.

which produce results which vie with, if they do not excel, the effects of natural sunlight and air. Illuminating engineers have dispelled the popular myth that artificial light need necessarily cause eye strain; they have been able to show that if the proper means are taken, artificial light can be made easier on the eyes than natural light. As clouds and smoke cover the sun many times a day, natural light is apt to be very uneven, whereas the soft rays from properly shaded mazda lamps make a very even light. Indeed certain engineers have gone so far as to vision the day when tall buildings may be built without any windows at all and solely dependent upon artificial means of illumination. Such windowless buildings, it is pointed out by Mr. Rudolph P. Miller, former Superintendent of Buildings in Manhattan, would be cheaper to construct and safer from fire, would provide greater wall space for office furniture, would allow purer air to be provided by mechanical means and would allow the office workers to concentrate upon their task without distraction from outside. We by no means advocate such buildings—we refer to them only as indicating the attitude of some modern engineers to the possibilities of artificial illumination.

*Modern
Illuminating
Methods
Eliminate
Eye Strain*

Similarly, modern science has made it possible to provide systems of ventilation and atmospheric control which purify and humidify the air, providing a more even and steady and purer air circulation than would be possible with natural ventilation. Not all modern buildings have installed such advanced systems of artificial illumination and scientific ventilation but the day is coming when all new buildings of any size will be required either by enlightened self-interest or by building code regulation to do so. Obviously, the larger and taller the structure, the more likely it is to provide the best which science can offer.

*Mechanical
Ventilation
Perfected*

But while conditions within our modern skyscrapers, on most floors at least, may be satisfactory from the viewpoint of public health—and indeed far more satisfactory than in most low buildings—it may still be true that some validity remains in the public health argument because the flanking

*Light and Air
Diminished on
Lower Levels*

of our streets with tall buildings does reduce the amount of fresh air and sunshine available at the street surface and on the lower floors of buildings and thus may impede the normal beneficial effect of these natural therapeutic agencies. This problem has not been sufficiently investigated to enable one to speak authoritatively. In December, 1926, the Height Limitation Committee of the National Association of Building Owners and Managers submitted the following questionnaire to a number of medical, public health and insurance experts:

"In making a study of Height Limitation provisions in Zoning Ordinances as they affect the so-called 'Skyscraper', I am extremely interested to determine the effect upon Life and Health and would therefore appreciate very much a statement from you on the relation of Streets, Street Cars, Department Stores, Theatres and Office Buildings to:

- "(a) Acute respiratory infections, such as Coughs, Colds, Influenza and Pneumonia, and, in a lesser measure, to Consumption, Diphtheria and Cerebro-spinal Meningitis;
- "(b) Eye Strain, Damage to Eyes, Headache, Fatigue and Working Efficiency.

"The proponents of Zoning and Height Limitation claim that the Skyscraper causes a detrimental effect upon Life and Health as it pertains to some of the above.

"To this day we have been unable to secure any information in support of the proponents of Zoning and Height Limitation and we have yet to find any proof to back up their arguments—on the other hand we have information which tends to discredit their arguments."

*Authoritative
Information
on Harmful
Effects not
Available*

Replying to this questionnaire, such authorities as Dr. C. E. Winslow, President of the American Public Health Association; Eugene L. Fisk, Medical Director of the Life Extension Institute; F. L. Grosvenor, Medical Director of the Travellers Insurance Company; Dr. J. Allin Patton, Medical Director of the Prudential Insurance Company of America, and Mr. Henry Bruere, formerly of the Metropolitan Life Insurance Co., stated that it would be impossible to produce statistical data to support either side or the controversy.⁽¹⁾ Dr. Haven Emerson of the College of Physicians &

(1) 1927 Report of Height Limitation Committee, pages 52 and 53.

Surgeons, Columbia University, New York, responded to the same questionnaire as follows:

"There is no unequivocal evidence of the damage to life and health due solely to the limitations of light and air movements by tall buildings.

"Briefly, the prevalence of the communicable diseases listed in your paragraph (a), bears no direct relation to the heights of buildings except as they contribute to the congestion and increase of close personal contact in streets and street cars.

"So far as the items harmful to health mentioned in your paragraph (b) are concerned, these are in no way necessarily due to any of the conditions created by tall buildings. All of these disabilities may and do occur abundantly where there are no tall buildings, and their occurrence can be readily prevented by suitable environment, light, air and working conditions even where skyscrapers prevail.

"The effects of department stores, theatres and office buildings upon the two groups of conditions you give are no different from such as occur anywhere among groups of people who fail to observe the laws of personal hygiene."

An authoritative answer to this whole problem apparently must await the results of further extensive investigation. However, it seems obvious that we can admit the desirability of making available as much sunlight and fresh air as possible and at the same time condemn as an exaggeration the description of our city streets as "disease-breeding canyons". In support of this position, it should be noted that the time spent on the streets by the average person is relatively small. Exposure to vitiated or polluted air might be serious, if long continued; if the exposure is fleeting or intermittent, little or no injury may result except in the remote contingency of the individual picking up a virulent disease germ. In the second place, other steps may be taken which will afford at least a partial remedy. For instance, we may, and should, vastly improve our street cleaning methods—European cities have much to teach us in this regard. Again, the use of bright facing materials which will reflect sunlight and can be readily cleaned, and the encouragement of periodic cleaning of our building exteriors would be of some assistance. Lee Thompson Smith, former President of the Building Owners and Managers Association of New York City, has expressed the opinion that a coating

*Criticism
Exaggerated*

of soot on a building is worse than ten extra stories. In a newspaper interview,⁽¹⁾ he was quoted as follows:

"Sunlight blotters—dingy, dirty buildings that sop up the light—are more of a menace than a few extra stories of clean, bright building reaching up into the blue"

"It (sunlight) is too precious a commodity in New York to permit its wanton destruction by soot and poorly planned buildings which are light killers from the first, which collect dirt and cannot be practically cleaned,"

"We have been shadow boxing long enough. There are more important enemies to fight than shadows. The worst wallop to the city's health and comfort comes from dirt and dark surfaces which waste the light that reaches them, instead of reflecting it downward to the street and neighboring buildings."

With due deference to Mr. Smith, we believe that a more serious theft of the city's supply of sunlight and pure air is perpetrated by the pall of smoke which results from ill-constructed furnaces and flues and the burning of unsuitable coal. On an average bright day the clouds of smoke particles that hang over New York like a floating curtain deprive the city of 37 per cent of its sunlight in the early morning and 14 per cent at high noon. This revelation was made recently ⁽²⁾ by Dr. James E. Ives of the United States Bureau of Public Health Service following several months of investigation in cooperation with the National Conference Board on Sanitation. It is clear therefore that New York's supply of sunlight and fresh air can be substantially increased without going to the extreme of putting an arbitrary limitation on building heights, the economic results of which it would be difficult to forecast.

Finally, we believe that in the setback principle which was incorporated in the New York Zoning Law in 1916, a principle has been discovered which can be used to provide a satisfactory assurance of a reasonable quota of light and air under all conditions. This principle has been outlined in an earlier section of this Report. Stated simply, it requires (1) that the street wall of a building should not exceed a stipulated number of times the width of the street, varying from

*The Setback
Principle Offers
Flexible Solution
to Light and Air
Problem*

(1) New York Times, January 15, 1928.

(2) New York Times, Oct. 30, 1927.

$\frac{1}{4}$ to $2\frac{1}{2}$ times, depending on the district; and (2) that from that point on the building should be set back so many feet (from 2 to $\frac{1}{5}$) for each foot of increase in height, except that a tower of indefinite height may be erected on an area not exceeding 25 per cent of the area of the lot. It is obvious that this principle accepts the argument which is based on the therapeutic effect of light and air. The precise application of the principle in the present New York law presumably represents a compromise between real estate values and hygienic necessities. Most observers believe that the compromise is a fair one—liberal enough to conserve the “reasonable” rights of the individual property owner, strict enough to safeguard in practicable measure the community’s interest in sunlight and air for the streets and neighboring buildings, flexible enough to permit of individual freedom in development and of ready adjustment to changing economic conditions.

It may be, however, that further study and experience will demonstrate the wisdom of some amendments. For instance, it has already been suggested by such distinguished architects and students of the skyscraper problem as Harvey Wiley Corbett and Ernest Flagg, as well as by Mayor Walker’s City Committee on Plan and Survey that the maximum height of street wall should be reduced in all districts to a lower number of times the street width, and that the process of setting back should then begin but should not go as far as required under the present law, thus allowing the owner to develop a tower of indefinite height on an area somewhat larger than 25 per cent of the area of the total lot. The suggestion seems to have merit. Lowering the street wall would increase the amount of sunlight reaching the street and lower floors of adjoining buildings but would of course involve some loss of rentable area; on the other hand, this area would not be the most valuable and the sacrifice of income which it would entail should be more than counterbalanced by the increase of the more valuable rentable area in the tower. Many towers are uneconomic today because restricted to 25

per cent of the area of the small lot on which they are erected; increasing the maximum size of tower to a greater proportion of the lot area would make such developments practicable.

In conclusion we quote the conclusion of F. W. Fitzpatrick⁽¹⁾, well-known architect, who also believes that in the setback building we have a means of reconciling the skyscraper with all reasonable demands for light and air:

"Health? Given a means of having more sunlight in our streets than we now have and therefore also more daylight and air in our offices (the setback building) I know no reason to cut down for that consideration either. All that can be done for sanitation, uncrowding, lighting, health in a three storied building can be done equally well in a twenty storied one. Indeed, the higher you go the better air, the less noise, the happier is your environment. Ventilation, street cleaning, smoke prevention, prevention of spitting, etc., would not be bettered because of lowering of our limits. Those things need accentuation in themselves.

"You'll find that health officers and experts have an infinitely more arduous task in getting the individuals into healthful ways and habits than in handling buildings and streets and inert matter. Given light and sun you can safely leave the rest of the detail to the health and sanitary departments, and height of the buildings need not be stressed in our minds. So with sewerage, water supply and such. Really, height means little in those respects. Even today I venture that our sewers, where they are modern, could take care of half a dozen more stories on each tall building.

"Aside from the scientific and statistical standpoint, it would seem as if the greatest asset of the high building, as regards health, is due to the psychology of cheerfulness, and medical men agree that cheerfulness is an asset to health. The offices in the high buildings get an abundance of light and air, and usually a pleasant outlook with the psychological result of cheerfulness, thereby aiding health. From the viewpoint of the building owner and manager, the modern tall building is not a menace to the health of the tenants and public, but on the other hand it offers many safeguards to the general health of all who must necessarily occupy and use these buildings."

In some discussions of the Public Health argument, the factor of noise is considered. Noises, it is said, are greatly increased by the reflection of sound waves from the hard

(1) 1927 Report of Height Limitation Committee of National Association of Building Owners and Managers, pages 55-56.

surfaces of pavements and building walls. Limitation of the height of buildings is therefore a means of noise reduction.

The argument is not one which is stressed by the critic or one which would appeal to the average man. The latter would be likely to take the common sense point of view that city noises are only a minor factor in public health and are due, not to the presence of tall buildings but to traffic, manufacturing processes and the erection of new buildings. Dr. E. E. Free, a consulting research engineer of New York City, has perfected a device to measure sound scientifically. He has taken measurements of sound at different points in New York City but "has never considered any practical value attached to taking these tests at different altitudes and locations. His tests indicate that noise is practically the same from the ground floor to the third floor, that it will start to decrease at the fourth or fifth floor, and is practically absent on upper floors of high buildings."⁽¹⁾

(1) 1927 Report of Height Limitation Committee of National Association of Building Owners and Managers, page 55.

V

THE PUBLIC SAFETY ARGUMENT

DANGER TO LIFE AND LIMB FROM FIRE, EARTHQUAKE AND TORNADO

Another indictment of the skyscraper which formerly played an important role but which is receiving increasingly less emphasis in recent years is the alleged danger to public safety involved in tall buildings. Originally, the basis of this indictment was the fear of a possible "collapse of one of these monster structures upon a crowded street". A generation of experience with skyscrapers—a generation crowded with one engineering triumph after another—has cast that fear into the limbo of forgotten terrors. More recently the argument has taken the form of the alleged dangers to life and limb which lurk in the possibility of either a serious fire or else of some natural catastrophe such as a tornado or an earthquake affecting a tall building. Such dangers, both in their direct and indirect effects, constitute, it is said, a menace which increases with the height of buildings.

*The Fire
Hazard*

That the fire hazard menace may be presented fairly, we may summarize the various points in the argument presented by the skyscraper critics before the Zoning Committee of the Chicago Real Estate Board in 1922. The occupants of tall buildings, it was said, are constantly in danger because a serious fire may make it impossible for them to reach the ground. The modern skyscraper may be fire resistive in construction but this would not prevent the contents of a building being completely destroyed by fire originating outside (as in the

Burlington fire) or inside (as in the old Equitable fire). Fire-proof enclosure of stair and elevator shaft is very desirable and often makes these exits usable during a fire but such enclosure cannot be depended upon for absolute safety in a high building because a single door left open, or a small crack, may permit such shafts to become filled with smoke or fire, rendering them impassable. Outside "fire escapes" are usable for a Fire Department but practically valueless as a means of escape for the tenant. City Fire Departments cannot effectively fight from the ground a fire in a building above 7 or 8 stories. Inside standpipes are often improperly installed and more often improperly maintained. Considerable danger to life is involved in the possibility of panic resulting from fire in a burning skyscraper.

While the indictment may at first sight sound impressive, it will scarcely bear the test of analysis. In the first place, a study of the extent to which advances have taken place in recent years in the development of fire resistive construction and in fire fighting equipment and technique will indicate to the fair-minded person that the fire menace has been reduced to a minimum in the modern skyscraper and that it is less there than in most other types of buildings.

Apart from the building owner and the tenant, there are three separate groups whose function and interest it is to guard against fire loss. The City Building Department is charged with the function of enforcing strictly the regulations of the Building Code. Inspection by this Department becomes effective when plans are filed for permit, periodically during the course of construction and again before a permit for occupancy is granted. The City Fire Department is responsible for inspection of the various features of the building with which they are strictly concerned. Buildings are ever subject to examination by a representative of this department both during erection and after. It is not only the duty of the Fire Department to inspect all structures periodically but it is also very distinctly to the interest of the firemen making the inspection to see that all fire-fighting equipment be kept in proper working

*Threefold
Inspection and
Supervision*

order to minimize the hazards of fire fighting. The third group, namely, the fire insurance underwriters, are obviously interested in reducing fire loss to a minimum. Moreover, as their requirements involve the levy of an additional percentage on the annual premium whenever a building rated by them in the highest class fails in certain points to meet the specified requirements for that class, they have an important lever with which to make the owner live up to their most rigid requirements.

*Fire Protection
Features of a
Modern
Skyscraper* Without attempting to give a complete description of the required exits, alarms, signals, and fire prevention equipment of a modern office building or to differentiate between legal requirements and underwriters' recommendations, we may refer to the more important fire protection features which are now being incorporated in most of the modern office buildings in New York City.

*Fire Tower
Stair* Stairs must be of ample size and number to accommodate at one time the total population of the building, computed on the basis of an amount of space per individual which is clearly defined in the Building Code. They shall be so distributed that no point in the building shall be more than 100' from the exit—or 125' when certain specified rules are complied with. The number of legal stairs in a building depends upon its size but every floor must be served by at least two, one of which is accessible only on passing from the public corridor to a court opening to the sky or through a balcony which has direct access to the open air and leads direct and independent of all other exits to the street. This air-link guarantees that this stair, known as a fire tower stair, shall always be free from smoke. The walls of such stair as well as those of its corridor balcony must be of brick at least 8" thick. As everyone knows, all legal stair doors should open out from the public corridor side and must remain unlocked from this side. In case of emergency one elevator must be reserved for the exclusive use of the firemen at all hours, night and day.

To guard against fire from the outside, all modern office buildings have metal windows and any openings on a property line other than the street must be glazed with wired glass.

George Henry Payne, Commissioner of Taxes and Assessments for New York City states⁽¹⁾ that the traffic controversy in New York City goes as far back as 1796 "when the agitation was over the fact that ox carts were clogging the streets near the East and North Rivers, in the neighborhood of the markets". He also cites various old engravings to show that serious traffic congestion existed in several parts of the city at various times throughout the nineteenth century. It existed with bus and horse-car lines and ferryboats fifty years ago. It was continued on the bridges and the elevated structures, and today we have it on the street surfaces and in the subways.

Traffic congestion has changed in form and scope, it is true, but it seems to have been an accompaniment of urban growth almost from time immemorial.

2. *Congestion is not peculiar to skyscraper cities. It is found in equal degree or almost equal degree in several cities where the tall building is practically non-existent.*

For instance, in London, which limits building height to approximately 100 feet above the sidewalk, business is spread over an enormous area with the result that the buses, trams, taxis, subways and every means of transportation are crowded with people moving to and fro carrying on their business. While the streets in relation to the height of buildings on them are narrower than in New York City, London has a topographical advantage inasmuch as it is a hub city with main arteries spreading out in all directions like the spokes of a wheel whereas Manhattan is a narrow island with only a few narrow north and south parallel highways. Observers⁽²⁾ declare and photographs⁽³⁾ seem to indicate that only a few sections of any American cities can produce traffic congestion more aggravated than or as aggravated as that which is found at Aldgate

Grave
Congestion in
Low-Height
Cities

London

- (1) Address on "The Skyscraper and Congestion" before the American Institute of Steel Construction, October 26th, 1927.
- (2) Alfred C. Bossom, N. Y. Times, Nov. 28, 1928; Harvey Wiley Corbett address before New York Building Congress, Jan. 17, 1927; George Henry Payne, address on "The Skyscraper and Congestion" before American Institute of Steel Construction, October 26, 1927.
- (3) 1927 Report of Height Limitations Committee of National Ass'n of Bldg. Owners and Managers, pages 34 - 36.

or Ludgate Hill, London. So serious is the situation that it is receiving the attention both of the London County Council and of the British Parliament. Drastic remedies have been proposed by the experts, such as overhead viaducts, more underground tubes, a minimum speed of ten miles an hour for all vehicles using streets during rush hours, barring horses from such streets, escalators for pedestrians, underground parking places for motor cars and buses, and gradual supersession of tramways by buses of larger carrying capacity than those now used.

Paris and Buenos Aires Similarly, if we take two other foreign cities where the skyscraper is conspicuous by its absence, Paris and Buenos Aires, we find the omnipresent problem of congestion, not so aggravated perhaps as in certain parts of this Continent, but nevertheless serious and growing steadily worse with population and business growth and the spread of the automobile.

Boston In this country, the experience of at least two cities seems to demonstrate that low buildings do not save a modern community from congestion. For about 25 years prior to 1925, Boston had a law restricting building heights to slightly more than 125 feet. This regulation has caused the business district to spread over a large area and, "apparently has brought into the district many automobiles which might not have been needed if business were transacted in a smaller area. Notwithstanding the low buildings, and the enlarged business area, and the fact that the congested district is served by subways; that street cars do not use the surface and that there is a greater percentage of street area than elsewhere, Boston has a traffic condition which is almost as serious as (sic) any tall-building city."⁽¹⁾ In other words, failure to substitute modern arteries of traffic for the narrow streets designed for conditions of a century or more ago has given Boston a serious case of the modern disease of congestion, and in the opinion of some experts at least, decentralization of the business area has aggravated rather than alleviated the

(1) 1927 Report of Height Limitations Committee of National Association Of Building Owners and Managers, page 5.

severity of its affliction. Los Angeles offers a similar case in point. Its ordinance limits building heights to 150 feet. However, in spite of the absence of skyscrapers and in spite of the relatively wide streets in this Western city, congestion exists and in serious degree. Some students of the local traffic situation believe that the congestion has been increased by the enforced spreading out of the business area and the consequently longer street journeys that have to be made by shoppers and others seeking to carry on their business.

Los Angeles

It was contemplation, particularly of the Boston situation, which led Dr. Miller McClintock, Director of the Albert Erskine Bureau for Street Traffic Research, Harvard University, and perhaps the best known American expert on traffic problems, to express the following perplexed comment⁽¹⁾ on the relation between building height and congestion:

Conclusion of a
Traffic Expert

"Confident conclusions in this field are elusive. Whenever one feels that he has come conclusively to the opinion that building heights ought to be limited he is almost inevitably jarred loose from this conclusion by a situation which seems to prove that building heights are not so important a factor in demand as we might have expected. Thus, for example, in the central district in Boston, where, as you know, there are rigid height limits upon structures of all types, there is a concentration of population of about 800,000 persons per day.

"In the Chicago Loop district, a much larger commercial area with no limits upon building heights, the concentration of population is only about 850,000 persons per day. How that can be explained I do not know, but it certainly does raise a very definite doubt as to the relation of building heights to the concentration of population."

3. *Not only does congestion exist in low height cities but it is also a grave problem in the low height sections of skyscraper cities. Indeed congestion is more aggravated in the retail and theatre sections than in those areas where tall office buildings are segregated.*

In New York, for instance, traffic congestion is far more serious on Fifth Avenue and in the Times Square section than

(1) Address on "Street Traffic and the Office Building" in Proceedings of 62nd Annual Convention of the American Institute of Architects, 1929, page 115.

Greatest
Congestion
not in Skyscraper
Sections of City

in the "city of skyscrapers" at the foot of Manhattan. It is true of course that in the latter or Wall Street section there is a pedestrian and a rapid transit traffic congestion three times a day—in the morning and evening when the office workers are coming and going and during the noon hour. But, as we shall see later, these types of congestion do not give rise to the difficult problems which result from the vehicular congestion which persists throughout most of the day in the retail sections and during the evening in the theatre section. Perhaps a more striking case is found in Chicago. In that city the tallest office buildings are concentrated, for the most part, on La Salle Street and on Michigan Avenue; yet on these thoroughfares traffic is much less congested than in the merchandising and theatre section on and near State and Madison Streets where the buildings are as a rule much lower. In San Francisco, the shopping traffic on Market Street is reported to be four or five times as dense as the traffic in the financial district.⁽¹⁾

Department
Store
Congestion

Figures collected by the Height Limitations Committee of the National Association of Building Owners and Managers seem to prove conclusively that the heaviest traffic is produced by department stores and theatres. In Detroit,⁽²⁾ for instance, one department store had a traffic for one day of 114,727 persons and another one of 88,920 persons, while the traffic in a large office building, 312 feet in height, was only 10,620 persons. Between 5 and 6 p. m., 16,575 persons left one department store and 13,275 left another, whereas the number leaving the largest office building was only 1,624. In Saint Louis,⁽³⁾ a study of 27 office buildings with 2,913, 064 square feet of office space showed a daily passenger traffic of 200,936 or 6.6 times the tenant population of the buildings; in the five large Saint Louis retail stores with a floor area of slightly over 1,000,000 square feet, the estimated daily total traffic was 613,500 or 52.6 times the permanent

(1) Chas. W. Smith, Exec. Secretary, Bldg. Owners and Managers Ass'n of San Francisco. Letter to L. O. Honig dated April 7, 1927.

(2) 1927 Report, page 6.

(3) 1927 Report, pages 6 and 7.

population. This comparison would be more enlightening if the total foot frontages of the two types of buildings were known but these figures are not available.

In further demonstration of the fact that tall buildings are not *the* cause of traffic congestion, the 1928 Report of the above Committee uses the following illustration drawn from another Eastern city:

"In the City of Pittsburgh there is a block on Fourth Avenue in the financial district which is solidly built up with tall buildings, most of them 150 feet or over in height. These buildings, due to a shortage of office space, have been 100% rented for the past several years, so that they (sic) have had ample opportunity to observe conditions as they would be at their maximum population per rentable square foot. Two blocks north, there is on Fifth Avenue a block of space located parallel to Fourth Avenue on which there is only one high building, the balance of the space being occupied by theatres, department stores, chain stores and restaurants. The sidewalk traffic on Fifth Avenue is almost ten times as great as that of Fourth Avenue and the street traffic is so great that parking has never been allowed, and for a time it was thought some means would have to be devised to remove the street car traffic. Fourth Avenue, on the other hand, had, until about eighteen months ago, parking regulations allowing machines to park for one hour, and even now, with parking regulations stringently enforced in the entire downtown district and all parking abolished on principal streets, there are never any serious tie-ups on Fourth Avenue and no congestion. Conditions, even from 4:30 to 5:30 p. m., when the occupants of office buildings are leaving for home, are infinitely better than on Fifth Avenue, at any hour of the day. It is a fact which may be easily proven that a two or three story department store or theatre will attract during the business hours more people than a twenty-story office building, regardless of its type of tenants."

A Pittsburgh
Illustration

If traffic congestion has long antedated the skyscraper, if it exists in low-height cities in practically as aggravated

form as in tall building cities, and if it is more serious in the retail and theatre sections than in the office building zones of our skyscraper cities, it should be clear that the tall office building cannot be either *the* cause or even *the major* cause of the evil. If any one factor can be selected as *the* cause, it is the rapid and tremendous growth of our urban areas, growth both in population and in business activity, growth unmatched by any corresponding expansion of our transportation facilities to take care of the new demands. Accentuating the normal effects of this record growth has come contemporaneously an enormous increase in the habit of travel, an enormous increase in mobility made possible by the automobile and the high level of prosperity widely diffused. Since 1915 the number of motor vehicles registered in the United States has increased from about 2,500,000 to over 25,000,000. This ten-fold increase in 14 years has not been offset by any corresponding improvement in traffic facilities. The significance of this from the traffic standpoint is multiplied when we remember that the automobile has increased even more rapidly in use than in numbers and that in its demand upon our traffic facilities it is a very wasteful form of transportation, involving as it does practically the substitution of individual transportation for mass transportation. Growth in population and in business activity, failure to adjust our traffic facilities to the new traffic demands, the increased habit of travel and the universal use of the automobile are therefore the major causes of the evil of traffic congestion. The tall office building is only one of the minor offenders. True, it does concentrate a large number of people upon a given spot—as already explained, its efficiency as an economic device is based upon its ability to effect such concentration of people and thus to facilitate the rapid and convenient handling of business transactions. But this concentration of people is not nearly so great as in the case of a large department store, while the traffic concentration which results is limited to three short peak-load periods (in the morning and evening when the office workers are coming to or going from

their offices and during the noon hour) and constitutes a burden primarily only upon the sidewalks and the rapid transit facilities. Such types of congestion are relatively easy to solve; it is vehicular congestion which is usually meant when traffic congestion is complained of and which confronts the modern city with problems of greatest cost and complexity.

Turning to a second major proposition, we believe that not only is the tall building not *the* cause nor even *the major* cause of traffic congestion but that to a degree it actually tends to relieve that congestion which is a concomitant of the growth of modern cities.

*Tall Buildings
Tend in Some
Ways to Relieve
Congestion*

As already demonstrated, it makes possible or at least practicable that high degree of regional specialization which modern commerce seems to require for the utmost efficiency. In an earlier section of this report, the role of the skyscraper in facilitating the development of specialized business districts in our urban areas was described and an effective illustration of the way in which this specialization resulted in a saving of traffic from the streets was quoted from an address by Mr. Corbett.

*They Facilitate
Regional
Specialization
of Economic
Activities*

This particular relief of traffic congestion, however, is probably of minor importance compared with the great saving due to the substitution of vertical traffic for horizontal traffic which the skyscraper effects. In other words, the elevator system in a modern office building is essentially a vertical street; on this vertical street is carried with unequalled efficiency and entirely at the building owner's expense a huge amount of traffic, much of which, in a city of low buildings, would take place upon the streets. The skyscraper, we have found, is the most efficient building known to man. It concentrates under one roof within quick and easy access of each other several thousands of men and women. The fact that these people can transact necessary business with each other without going into the street and the further fact that any person from outside, salesman or customer or what not, can visit any group or all of the tenants in the building without

*They Lead to
Substitution of
Vertical Elevator
Traffic for
Horizontal Street
Traffic*

using the streets more than once, indicate that the amount of traffic taken off the streets by tall buildings is very considerable. Where the building has an entrance to a subway within the building itself or where it can be connected either by underground passage or overhead bridge, with buildings located across intervening streets, additional important relief is given to street traffic. The substantial relief afforded by subway entrances within buildings is strikingly demonstrated by conditions in the group of tall buildings surrounding the Grand Central Terminal, New York City.

*Specialized
Buildings
Reduce Street
Traffic*

Where regional specialization has gone to the point of specialized buildings or where a tall building is occupied wholly by a single or a few inter-related firms, or where the building offers multiple or combination services, the amount of traffic which is saved from the streets is obviously much larger. As noted above, there is a tendency in all three directions. More and more buildings are being designed for the use of a single trade or profession, or group of trades or professions; thus we have the Architects' Building in New York City and Medical Arts or Professional Buildings in nearly all large cities. Again, many of the insurance companies, public utility companies and other large corporations are building tall buildings in which all their own and related organizations may be concentrated. The new building of the New York Telephone Company is an excellent illustration of how such a structure may contribute both to public and to private efficiency. Mr. Harvey Wiley Corbett has cited another striking instance. Speaking of the 22 story building which he designed for a utility company in a small Pennsylvania town which had no other buildings over four stories in height, he made the following statement in an address before the New York Building Congress:⁽¹⁾

"This structure is being erected for an enormous concern—the Pennsylvania Light and Power Company—and their employees at the present time are scattered throughout that town in twelve or fifteen buildings. These employees come to town in motors and these cars stand on the street in front of these buildings.

(1) Buildings and Building Management, January 17, 1927, page 38.

In order to carry on business these people have to move about. This building will allow all of these people to come under one roof and give them vertical circulation as a means of communication in their work and keep them off the streets throughout the whole working day."

Finally there is the increasing tendency to combine several functions or services in a single building in order to make it as self-contained as possible. Thus all large modern skyscrapers have one or more restaurants; many of them have clubs on the upper floors; practically all have drug stores, barber shops, medical and dental offices and ground floor or basement shops in which can be purchased most of the articles likely to be in daily need; many buildings have direct access to subway or other rapid transit facilities without requiring use of the streets; and a few buildings, such as the Fisher Building of Detroit, have integral garages into which the tenant may drive his car and then proceed directly to the elevator. In a few cases, a beginning has been made in the combination of residential and office facilities in the same structure. Instances of this combination are found in New York but perhaps the best example is the combination of hotel, apartment, office, store and railway terminal facilities in the great structure or group of structures constituting the new Van Sweringen Terminal in Cleveland. As we have pointed out in an earlier section of this Report, there are not a few students of city growth who believe that we must ultimately solve part of the tremendous problem of transporting people back and forth from the residential to the business zone by restoring "the old-fashioned idea of the living quarters above the shop", not of course in the old way but by a composite skyscraper whose lower 20 or 30 stories would be devoted to business and its upper 30 or 40 to residential use. It is interesting to note that if the time comes when the separation of business and residence is found to be economically inadvisable, the skyscraper will provide an efficient device for reuniting these two functions. The effect on traffic would be obvious.

*Statistics of
Elevator Traffic*

It is unfortunate that adequate statistics of elevator traffic are not available to enable us to make quantitative estimates of the effect of vertical traffic upon horizontal traffic in the streets. We do have certain figures as to the amount of elevator travel in individual buildings or groups of buildings. According to Mr. Clarence T. Coley, Operating Manager of the Equitable Building, the 48 passenger elevators in that great structure carry on the average 96,000 people per day between the hours of 8 a. m. and 6 p. m. During the course of a year they travel 275,000 miles, or 11 times around the earth at the Equator, each car carrying 6 persons for every mile. The building has 40 stories, 1,220,688 square feet of net rentable area and a permanent population of 12,000. The people passing in and out of its various portals each day number 135,000. The real estate management firm of Cushman & Wakefield has had a count made of the number of passengers carried by the elevators in sixteen office buildings under its management in the Grand Central Zone of New York City.⁽¹⁾ The sixteen buildings had a combined height of 303 stories and were serviced by 75 elevator cars. During the year 1928, including 305 working days between the hours of 8 a. m. and 6 p. m., 36,089,850 persons were carried by the elevators. The 75 cars made a total of 4,960,170 trips equal to a total of 415,041 miles. These figures, inadequate as they are, give us some idea of the enormously heavy traffic carried by the "vertical streets" of New York City. Would this traffic be as quickly, as comfortably and as cheaply carried in a decentralized city?

*Inter-Floor
Traffic in
Skyscrapers*

Still less adequate are the statistics of *inter-floor* traffic in modern office buildings. The Equitable Building again comes to the rescue with some illustrative data taken from its comprehensive operating records. In this building, 6 of the 48 elevators are reserved solely for inter-floor traffic and the demand would take care of at least two more. These 6 elevators, carrying 14 persons to the car and serving every floor from the second to the thirty-eighth, leave the second floor at one

(1) New York Herald Tribune, Sept. 29, 1929.

minute intervals and empty and refill themselves on the average 3 times during the round trip. This means that every minute about 40 persons are working through the building. This of course does not include all the inter-floor traffic in the building. According to Mr. Coley, inter-floor traffic is so important that all new office buildings which aspire to give what would now be regarded as approximately ideal service must provide several inter-floor elevators.

In proportion as the building's tenant corporations are few in number and linked together by common ownership or other close affiliation, the proportion of inter-floor traffic becomes greater. Mr. Earle Shultz, Building Manager for the buildings owned by the Commonwealth Edison Company of Chicago, reports as follows in a letter dated October 21, 1929:

"In our group of buildings here, we find that the amount of inter-floor traffic is approximately 50% of the main floor traffic. The main floor traffic is very largely traffic between home and office and between office and lunching place. During the off-peak hours the inter-floor traffic materially exceeds the main floor traffic, thus indicating that more business is done between tenants in the buildings than with tenants in other buildings. Of course, our situation is somewhat special due to the fact that the building is occupied entirely by one group of companies under common ownership. At the same time, if these companies could not be in one building, the contacts necessary between them, if they were spread out over the city, would certainly add materially to the traffic problem."

The collection of similar statistics for a large number of buildings would greatly assist in solving this controverted question of horizontal versus vertical transportation. A mathematical attack upon the problem has been made by Professor H. D. Simpson of the Institute for Research in Land and Public Utility Economics, Northwestern University.⁽¹⁾ In the pure type of Main Street city where all business buildings are located on one street and all traffic traverses this street, he demonstrates that the *average* volume of traffic is neither increased nor diminished by piling up ten one-story buildings on a single street into one ten-story building, other

*Mathematical
Study of Effect of
Increased Height*

(1) National Municipal Review, June, 1928.

factors remaining the same. True, the population of the single building has been multiplied by ten but the average length of the pedestrian trips has been divided by the same factor. In other words, there has been merely a substitution of vertical elevator traffic for horizontal street traffic. When he turns from the Main Street city to the gridiron city, he finds the same effect on traffic but not to the same extent. Assuming that multiplying the height of buildings by x multiplies net rentable area and therefore number of tenants by the same factor, he applies the geometric theorem that like dimensions of similar areas vary as the square roots of the areas, and finds that the net effect on traffic of multiplying building height by x , other things remaining equal, is to multiply the average amount of traffic by the square root of x . The number of people in the smaller area with the higher buildings is multiplied by x but the average length of trip is reduced by a factor equal to the square root of the factor of increased height. Hence average traffic is increased by \sqrt{x} . To the extent that total traffic is made up of through traffic, his calculations show that the maximum effect of increased building height must fall short even of the square root of the factor of increased height. Two additional qualifications of his results must be made. First, in a city where setback regulations are in effect, increases in building height fall far short of producing equal increases in net rentable area and therefore in building population. For instance, the net rentable area of our 75 story building is not 5 times but only 2.2 times that of our 15 story building. Secondly, to the extent that inter-floor traffic took place, the effect of increased building height would be diminished. Summarizing, Dr. Simpson's analysis indicates that the maximum possible effect of increased building height (other factors remaining the same) on pedestrian and vehicular traffic is something less than the square root of the factor of increased height; that its minimum effect may be zero; and that, depending on the type of layout of the city, the effects will range somewhere between this maximum and this minimum.

It should be emphasized that the above effects relate to the *average* amount of traffic—the figure that would be obtained by taking an average of the counts of traffic passing each building. Further analysis would demonstrate that, if precisely the same assumptions be made in both cases, the *total* amount of traffic upon the streets would be several times greater in the scattered, low-building city than in the compact, high-building city of equal population and that the maximum congestion at the most congested point would be the same. The first conclusion follows naturally from the facts that the number of persons travelling is the same but the average length of trip in the first case is much greater.⁽¹⁾ In regard to the second conclusion it may be objected that it follows only because we assumed all factors to be the same, which would not be the case in actual practice. In other words, we assumed the same number of entrance or exit points (subway stations, for instance) in each case whereas the spread-out character of the low-building city lends itself more readily to a greater number of these than does the high-building city. In a physical sense there may be some truth in this claim; in an economic sense it has not so much validity, as it is great demand, great traffic concentration, that makes subway routes, subway stations, and other expensive rapid transit facilities practicable. In any case it emphasizes the fact that such things as the number of traffic entrances and exits are of even greater importance in traffic congestion than some of the more frequently criticised factors.

*Importance of
Other Factors
Such as Number
of Traffic Stations*

Finally, granting that traffic congestion is a very serious problem in our leading cities and even that tall buildings may contribute to it by creating peak-loads of pedestrian and rapid transit traffic in certain limited areas at certain limited periods during the day, we believe that this is not necessarily an argument for arbitrary limitation of building heights. On the contrary we believe that traffic congestion is a problem of growth which can be progressively solved by the applica-

*Logical Remedies
for Traffic
Congestion*

(1) Not only would the average length of trip be greater, but the speed of traffic flow would be reduced because of the greater number of traffic intersections on the average per trip.

tion of more direct and more logical remedies without incurring the danger of blocking progress in a natural direction and thus giving rise to new and unexpected problems.

It is difficult to discuss remedies for traffic congestion without reference to a particular city. In the discussion which follows, however, an attempt will be made to summarize in a general way the major remedies that have been suggested by such traffic authorities as Dr. Miller McClintock of Harvard University, Dr. Ernest B. Goodrich and Mr. Harold M. Lewis of the Regional Plan of the City of New York and Its Environs. Not all remedies suggested can or need be applied in all cities.

Reduce Demand
by "Staggering"
Traffic

One remedy which has been receiving increasing attention in New York and Chicago is based on the principle of *reducing the demand* upon the traffic arteries at the peak load periods. In other words, an attempt is made to spread out over a longer period the traffic and transportation demands of the central business district by "staggering" the opening and closing hours of organizations using office and commercial buildings.

For instance, in New York City as a result of an investigation conducted under the auspices of Dr. Lewis I. Dublin of the Metropolitan Life Insurance Company and of the Department of Public Health, various life insurance, fire insurance, and surety companies have undertaken to change their opening and closing hours in such a way that they do not coincide with similar hours for the majority of business concerns in the office building districts. More recently, opening and closing hours of different types of theatres have been staggered in order to reduce the evening congestion in the theatre district.

In Chicago as a result of a traffic study made by Dr. McClintock, a plan was devised whereby department stores and other merchandising establishments which draw into the Loop district a tremendous number of employees and customers, would arrange opening and closing hours off the peak of the office building rush, opening, say, at 9:30 and closing

at 6:00. Not only would this reduce the very abrupt traffic peaks around 9:00 o'clock in the morning and 5 o'clock in the evening but the 6 o'clock closing proposed would provide a full hour during which it would be possible for office employees, now practically excluded from any shopping except of the rush character, to consummate purchases requiring some selection and judgment. The new suggestion will shortly be given a thorough trial in Chicago.

A second general method of solving the traffic problem involves merely *the better use of existing facilities*. In many cities congestion is due more to the inefficient use of street area than to the lack of it. Greater efficiency in the use of existing facilities may not solve the whole problem but it is the cheapest remedy available and should be made use of to the utmost.

*Better Use of
Existing Traffic
Facilities*

In the last ten years, traffic regulation has developed into a science. First assigned to the police department primarily because accidents were frequently involved, it has increasingly been approached as a technical engineering problem and in the last three years fourteen American cities have established traffic engineering divisions. Within the last five years, control of street traffic by manual or mechanical means has developed. Today the synchronized "Stop" and "Go" systems are being superseded by various types of automatic progressive systems designed to permit a continuous flow of traffic. That such better control of traffic is able to provide a substantial increase in the effective capacity of already crowded streets is proven by what Dr. McClintock has been able to do in Los Angeles and Chicago. In the former city where before engineering control operations were undertaken in 1924 the streets were literally filled to their capacity, "the effective capacity of those streets was increased by approximately fifty per cent" by a better means of control which cost the city nothing. "Likewise," says Dr. McClintock,⁽¹⁾ "in the Chicago Loop District, where conditions were very congested only a few years ago, a series of control

Traffic Control

(1) Op. Cit., page 117.

methods, including the prohibition of left-hand turns, the introduction of a coordinated progressive control system and the application of prohibited parking, has served to increase very substantially the capacity of the streets of the central district and thereby has increased the accessibility of the office buildings and other structures located within the district."

*Regulation of
Commercial
Deliveries, etc.*

Provision of truck loading facilities within the property lines, either voluntarily as a result of the enlightened self-interest of private merchants and manufacturers or compulsorily by city ordinance; regulation of delivery hours, tending to elimination of day deliveries of merchandise by express companies and retail merchants; consolidation of trucking routes and trucking service, thus reducing the necessity of so many only partly loaded trucks making so many separate trips; store door delivery by the railroads between their rail terminals and shipper or receiver; and joint motor truck freight terminals for L. C. L. freight are other important methods whereby limited street surfaces can be made more adequate for necessary day-time use.

*Solving the
Parking Problem*

More important is the solution of the ever-present parking problem. Everybody would agree that street space is normally too valuable to serve as a garage; yet the extent to which it is used for this purpose in most cities is a serious cause of existing congestion. While complete prohibition of parking in the streets may be neither possible nor desirable under most conditions, careful limitation of parking time is absolutely necessary. The whole problem, however, will not be solved until more ample provision is made for parking facilities in or near the business districts, either by erection of terminal storage garages on the edge of the business district or by the skyscraper garage within the central district or by the so-called integral garage, the garage which occupies a number of lower floors or the central court of an office building as in the case of the Russ Building, San Francisco, the Fisher Building, Detroit, and the Pure Oil Building, Chicago. Zoning or building regulations in certain cities now make the application of this remedy legally impossible.

Most suggestions for traffic relief, however, involve methods of *increasing the supply* of transportation facilities.

In the rapid transit field, this involves increased provision for subways, bus lines and possibly tramways or elevated railroads. The street railway and the elevated structure play a diminishing, but under certain conditions, perhaps a necessary role in most large cities. As individual transportation by means of the automobile more and more monopolizes the street surfaces, mass transportation in underground subways becomes increasingly important. When a city attains a population of approximately 1,000,000, it can support, and usually requires, a subway. Increase of population beyond that point and peculiarities in the city's topography and layout determine the requirements for additional facilities. "The ability to provide rapid transit, mass transportation," says Dr. McClintock, ⁽¹⁾ "is almost unlimited. Physically it is unlimited, for it would be possible to provide in Manhattan Island, for example, an almost infinite amount of transportation by anything like a full utilization of the sub-surface area available. The only question is as to whether or not the economic advantage of a compact, highly built office building district is adequate to warrant the expenditures necessary to provide the transportation". In the writers' opinion, the answer to the last question is in the affirmative—for reasons already outlined in this paper. Capital costs for the construction of new subways in New York City are admittedly enormous but so great are the benefits of location at or near "the center of a market" and so great the advantages of the most rapid transportation to that location that under the free working of economic forces the requisite facilities would be provided and would show a satisfactory return upon the huge investment required. The trouble is that in most of our great cities, politics has bedevilled a situation where private enterprise has not shown the usual standards of foresight and enlightenment. With fares restricted by real or alleged political exigencies, with the facilities provided representing no

*Increasing
Supply of
Traffic
Facilities*

Rapid Transit

(1) Op. Cit., page 116.

thoroughly worked out, properly coordinated system of transportation, and with management apparently unresponsive to modern ideas of public service, we get results which are far from satisfactory either to the public consumer or to the private producer. Despite the dirty and crowded cars, however, the amount of transportation that can be bought for a nickel on the subways of New York City is probably the cheapest product of American industry. We do not here undertake to pass upon the present 5 cent fare controversy. We do say, however, that if a 7 or a 10 cent fare is really necessary to provide adequate, rapid, safe and comfortable transportation to the central business districts of New York City, the public can afford to pay it and will pay it gladly to a management that is prepared to meet the obligations on its side.

*New or
Wider Streets*

One of the most obvious methods of relief is to increase the width of existing streets and to open up new thoroughfares. It is the most obvious program because the fundamental cause of our traffic troubles today is the fact that our streets were laid out by our grandfathers in the era of horse-drawn vehicles and in the days of small things both in population and in commerce. Doubling, trebling or quadrupling of the city's population and commerce has since occurred and, what is worse, the automobile has come and conquered. The automobile is in some ways one of the most wasteful means of transportation, because it has meant the displacement of mass transportation by individual transportation. For instance, whereas the street railway upon which our cities were largely dependent 20 or 25 years ago ordinarily carried from 20 to 50 people per car, statistics collected in New York City indicate that the average automobile on the streets of that city carries on the average each trip less than one person in addition to the driver of the car. Further, the amount of street surface occupied by the automobile is very large—approximately 100 square feet for a standing machine, 200 square feet for a car moving slowly and 300 or 400 square feet for a car moving at the rate of 15 or 20 miles an hour. It is little wonder that

streets designed a century ago should fall far short of being adequate for today's requirements.

*Removing Errors
in Street
Layout*

In addition, in certain cities, notably New York, whose geographic characteristics present unusual traffic difficulties, serious errors were made in the original street layout. For instance, the street pattern of Manhattan, which is an island 13½ miles long and less than 2 miles across at the widest point and which has now about 500 miles of streets, goes back to 1811 when a Commission, appointed by Mayor DeWitt Clinton, prepared a map for that part of the old city extending from the developed area south of Houston Street and Greenwich Village northerly to West 155th Street. This map made provision for a series of parallel north and south avenues, each 100 feet wide and spaced 610 to 920 feet apart, while at right angles were located a series of parallel east and west streets, 200 feet apart, with widths of 60 feet, except at intervals of 7 to 15 blocks where widths of 100 feet were established. It is now clear that since the dominant direction of traffic upon the Island of Manhattan is of necessity north and south-bound, the closer spacing should have been between the north and south avenues rather than between the east and west streets. Further, not only are great arterial highways conspicuously inadequate but the street system is full of bottle-necks and dead-end streets and the absence of alleyways has increased traffic congestion by throwing the loading and unloading burden upon the streets.

The reader will be able to recall numerous instances from many cities where widening of streets (1) or the breaking through of new thoroughfares has provided important traffic relief. It is clear, however, that in such highly developed areas

(1) "There is a practical limit to the widths of roadways. Within our cities four or six moving lanes of traffic on a single roadway are about the maximum desirable. Beyond that, an inefficient use of the lanes caused by a shifting of vehicles from one to the other, and the increased difficulty and danger for cross traffic, both vehicular and pedestrian, bring many disadvantages. To get the maximum efficiency of roadway space it should be divided by curbs into sections of a two-lane width, and these subdivided by lines upon the pavement into separate traffic lanes—" Harold M. Lewis, in *Municipal News and Water Works*, April, 1929, page 138.

as the central business districts of New York, Chicago, etc., relief from this source is now limited because of the tremendous cost. Usually street widening in such cities involves the complete destruction of the buildings affected as well as heavy consequential damages to land and frequently leaves the frontage so badly gored as to be unsuitable for future substantial use. It has been estimated that to cut a new express street 100 feet wide through the heart of the Borough of Manhattan would cost about \$25,000,000 per mile.⁽¹⁾ Nevertheless, there are cases where such drastic methods for increasing the capacity of traffic arteries may and should be followed. The estimated cost may seem astounding but it may be necessary to avoid a much heavier cost for a necessary solution of the problem later on.

City Planning Projects for widening streets or the opening up of new thoroughfares should be part of a comprehensive city-planning program developed with the aid of competent experts and based on a most elaborate scientific study of the city's present economic pattern, the extent and character of its probable future growth, present traffic conditions, estimated future needs, probable trends in character and direction of traffic, etc. In Dr. McClintock's words, "Any city that is growing, or has hopes of growing, that is not attempting to rectify its old horse and wagon streets and adjust them to the requirements of the modern commercial age is certainly losing opportunities for which it must pay very dearly in the future". In particular, planning of this type should provide adequately for the great arterial thoroughfares leading into and out of the central business district, should distinguish between the different requirements of business and residential use and should see that every advantage is taken of the opportunity to *by-pass* through traffic so that it will not be necessary for it to pass through the crowded business sections of the city. A broad program of this general type was recently

By-Passing

(1) Arthur S. Tuttle, "Increasing the Capacity of Existing Streets" in Proceedings of American Society of Civil Engineers, May-August-September 1924, page 2.

outlined for the New York metropolitan area by the Committee on the Regional Plan of New York and Its Environs, an organization of public-spirited citizens, city planners and engineers who for several years have been carrying on extensive investigations under the auspices of the Russell Sage Foundation. The comprehensive plan which it has recommended in preparation for a community of 20,000,000 people by the year 1965 involves a network of regional highways, including a metropolitan loop, inner routes, radial routes, outer circumferential routes, a metropolitan by-pass, express highways and supplementary routes; new railroad belt lines; connections with old lines and new waterfront lines and union passenger terminals; a coordinated suburban rapid transit system; extensive tunnel and bridge connections—all synchronizing with an ambitious scheme for new parks, playgrounds and aviation fields. Of particular interest are the emphasis upon by-passing and the great circumferential or belt routes which will allow traffic to pass between the five city boroughs and indeed between all parts of the metropolitan area without increasing the congestion in the crowded business sections. If such planning for the commercial and motor age had been put into effect twenty-five or fifty years ago, traffic conditions in our cities today would probably be reasonably satisfactory.

Where streets have been widened it has been primarily to relieve vehicular congestion. In some cases, the width of roadways has been increased at the expense of the sidewalks and consequently of pedestrian traffic. Where this latter type of traffic has reached the saturation point, a remedy which is possible and which has been applied in some cases by private property owners is the arcaded sidewalk. "The sidewalk set within the building line," says Dr. McClintock⁽¹⁾, "offers such advantages in public comfort, and in good merchandise display as well as in added street capacity, that its widespread use in the future seems inevitable. Office buildings constructed in rapidly growing districts should be designed so that

*The Arcaded
Sidewalk*

(1) Op. Cit., page 117.

arcaded sidewalks may be later provided even though they are not originally included". Outstanding examples of this device are found in the 15th Street arcade in Philadelphia, the New York Telephone Company's building arcade on Vesey Street, New York City, the second story arcades in Chester, England, and the street level arcades in the Rue de Rivoli and the Rue de Castiglione, Paris. Somewhat analogous is the ordinary building arcade consisting of a walkway leading directly through a large building and connecting two thoroughfares. The Equitable and Chanin Buildings in New York City and the Mercantile Arcade in Los Angeles are examples. Not only do these arcades provide additional sidewalk and pedestrian capacity but they likewise provide very valuable frontages for commercial shops. In buildings covering entire blocks such as our study has led us to recommend for the central high land value section of metropolitan centers, either one or two arcades of this type would almost universally be provided.

*Grade Separation
of Traffic*

Another method of traffic relief involves a new principle of street construction, namely, grade separation. Even cursory analysis will indicate that traffic interference at street intersections is the primary cause of the inefficient use of existing street surfaces. "If you assume," says Dr. McClinck⁽¹⁾, "two highways meeting at grade, each with a demand for its full capacity, and then conceive of the traffic control devices necessary to take care of alternating it fifty-fifty for each road, you will see that under the most efficient conditions the capacity of each road would be reduced to 50 per cent. Actually the capacity is reduced to 35 or 30 per cent, because in starting and stopping there is additional lost motion and lost time." Improved methods of traffic control may tend to raise this efficiency percentage⁽²⁾ but the only effective solution is the separation of highway grades so as to

(1) Municipal News and Water Works, April 1929, page 146.

(2) An interesting suggestion to diminish the evils of cross traffic at the intersection of thoroughfares involves planning the crossing in the form of a circle (as in the Place de la Concorde, Paris) and requiring all traffic to go around in the same direction—to the right. Straight-ahead traffic would go around half the circle and traffic bound for the left turn would go around

permit uninterrupted movement in all directions. In Dr. McClintock's opinion, "the planning feature of the future American city, so far as the trunk lines are concerned, will be the construction of elevated streets, carrying traffic without grade interference and with country highway speeds". Chicago has already several examples of such super-highways—namely, Wacker Drive and the outer drives along Lake Michigan. Manhattan has begun the construction of an elevated highway along the Hudson River and has decided to go ahead with another similar highway skirting the East River. Less ambitious schemes involve grade separation at certain key locations only, those at the Grand Central Terminal and the Grand Concourse being important New York illustrations.

Various elaborate applications of this principle of grade separation have been suggested for congested business centers by such constructive thinkers as Harvey Wiley Corbett and Ernest Flagg. Mr. Corbett, for instance, suggests that the traffic which runs on rails should be kept underground; that the surface of the ground should be reserved for wheel or motor traffic; and that pedestrian traffic should be provided for in arcaded sidewalks at the second story level with bridges across the streets at street intersections. Under this system, the public would arrive at a zone in which this traffic system had been put into effect, would park their cars in ample parking space under the buildings, would rise one story by stairway or escalator and would then move through the shopping district with great comfort and convenience. In Mr. Flagg's modern city, all buildings would be set back 25 feet at the second story level; slow-moving vehicles would use the present street surfaces; fast moving automobiles

*More Radical
Solutions*

three quarters of the circle. A number of the points of right angle intersection in the traffic lanes are in this way changed into points of tangential meeting and parting, and if the traffic is not too heavy it can flow continuously from both thoroughfares, thus eliminating the annoying start and stop with its 50% loss of efficiency. Practical as this plan may be for the main streets of the average town it is far from a cure-all in solving the problem of crossing the dense and rapid traffic of the modern metropolitan thoroughfares. The circle also requires that a great deal of space be given up to street use in the very place where the land values are highest.

would use special express runways at the one-story level, centrally supported on the axis of the avenues and connected with the street surfaces by inclines; while pedestrian traffic would use the 25 foot setbacks, crossing street intersections by means of bridges. Both schemes contemplate that the change should be made gradually by requiring either that new buildings frame their steel so that a second story arcade could be provided when required or else that they set back 25 feet above the second story level. To the realist these suggestions may seem somewhat futuristic and imaginative today; the time is not far distant, however, when the one or the other with or without modification will be tried out in one or more of our leading cities. Dr. McClintock, for instance, believes that in many densely built areas, it will ultimately be necessary to provide second story sidewalks arcaded into the building with bridges crossing intersecting streets and that the "plan might well be anticipated in the design of new structures".

*Growth Will
Always Create
New Problems*

By the application of some or all of the above remedies, the traffic situation in our urban centres can, in the opinion of the writers, be made measurably satisfactory. In a growing city, it perhaps will never be perfect—certainly not for any considerable period. For growth will give rise to new problems which must be met and solved as they arise. There can be no such thing as a permanent city plan for a progressive, growing city.

*An Alleged
Vicious Circle*

It will, of course, be said that the suggested remedies are mere palliatives—that they may give temporary relief but will not effect a cure. Indeed the charge is that the ultimate effect will be still further to increase congestion—in other words skyscrapers lead to congestion, new transportation facilities are erected to relieve this congestion, new skyscrapers are built to take advantage of more rapid transit to the center, increased congestion again calls for more transportation facilities, and so on indefinitely in a vicious circle.

Hence, the critics assert the only real cure is drastic limitation of building height (or of building cube) in relation to the width of streets. Today it is said that street capacities are

limited while the height (or cube) of buildings fronting on the streets is unlimited, whereas what is required is building height (or cube) limited to street capacity. This formula sounds plausible but is subject to two serious criticisms. In the first place, no logical relationship has yet been worked out between building height (or cube) and street capacity. We have submitted evidence to show that the relationship, if it exists, is at least not a simple one, that it varies greatly with the building's purpose and with many other factors, and that it changes with changing conditions such as growing specialization of business districts. Certain estimates have been made of the relative extent to which buildings used for office, loft and store purposes⁽¹⁾ cause traffic demand upon the streets but the factual data are too meagre and the variable factors too numerous and uncertain to provide a formula that can be accepted with confidence for the solution of so far-reaching a problem. Ultimately perhaps adequate statistics and adequate research may disclose all the secrets of this congestion problem but such statistics have yet to be assembled and such research has yet to be completed. In the second place, a flat level restriction of this sort would mean an end to *growth*. It would block further progress and development in areas where economic forces are operating at maximum pressure and in a field where dynamic change is ever present. It would stereotype a city plan determined by the limited needs and narrow vision of our grandfathers. No city or central district which is growing or hopes to grow would tolerate such blocking of progress. If it be said that the effect would be merely to spread the central business district over a wider area or to cause the development of subsidiary centers, the answer is that in some ways this would increase the volume of traffic rather than decrease it, that the net effect on traffic congestion would be by no means clear and that the sacrifice of business efficiency would probably be great.

It is true of course that some measure of decentralization

*Objections to
Accepting
Present Traffic
Facilities as Final*

(1) Mr. Ernest P. Goodrich, in Proceedings of International Town Planning Conference, 1925, pages 439-455.

Concentration and
Decentralization
Taking Place
Side by Side

is taking place all the time. Cities grow *outward* as well as *upward*. That is the inevitable result of the perpetual competition among economic activities for advantageous locations, which was described in an earlier paragraph. The weakest bargainers are being constantly pressed to the outer rim. Not only that but in city growth (the utilization of urban land) as in other fields of economic activity the familiar principle of diminishing returns is at work. At any given stage in economic development the gains from more *intensive* utilization of a given plot or district will begin to be offset at some point by increased costs. After this point is reached, pressure will make itself felt for *extensive* utilization—in other words for decentralization. Intensive and extensive development—concentration and decentralization—are proceeding side by side at all times in our great cities. If the central business district is really becoming less efficient as a result of the rising costs of traffic congestion, if it has passed the point of diminishing returns, competing centers will spring up and flourish. The only plea that is made here is that this development should be allowed to take place naturally. It should not be forced by *arbitrary* restrictions upon the development of the central district. In Professor Haig's phrase "the forces of competition do tend to approximate the ideal layout, and the trends actually in operation are the surest indication as to what is economically sound." This does not mean that city planning and zoning have no place. Quite the contrary! It means merely that deliberate planning of city development should be intelligent and based upon sound economic analysis, that it should be flexible rather than arbitrary, that it should regulate rather than block the natural working of economic forces, that it should prevent parasitic development by making each economic activity bear its own fair costs rather than by attempts at arbitrary prohibition. Further, in the face of such powerful economic forces as are moulding a city like New York, it should be humble. Reason for this is found in the following statement made by Professor Haig in regard to one of these forces: "The technique of

Wise Policy
is to Substitute
Flexible Regulation
of Competition for
Arbitrary Flat
Level Restrictions

transportation is a veritable volcano of possibilities whose unpredictable eruptions may be devastating in their effects on predictions of population distribution".

VII CONCLUSION

In this extended discussion, the authors believe that they have succeeded in demonstrating the following major points:

*Major
Conclusions*

1. The claim that the skyscraper is an economic fallacy is without foundation. Given the high land values in the central business sections of our leading cities, the skyscraper is not only the most efficient, but the only economic utilization of certain strategic plots. An exhaustive investigation of possible alternatives for the development of a specific plot of appropriate size and location in the Grand Central Zone in New York City has conclusively demonstrated that the factors making for diminishing returns in the intensive development of such plots are more than offset by the factors making for increasing returns until a great height is reached, thus establishing the point of maximum economic return or true economic height for such sites at an unexpectedly high level. True economic height is the resultant of a great many variable factors, of which the two most important are the size of the plot and the value of the land. Such economic height must be determined as an individual problem for each particular site.

2. One of the important real estate trends of the future in central business districts will be the development of very large plots, probably entire city blocks, with single huge structures rising to very great heights. Other important trends will include the increasing specialization of business districts and of office buildings, and the development of multi-purpose

structures in which the tenant will be able to satisfy practically all his wants without passing beyond the four walls of the building.

3. Flat level or arbitrary restrictions upon building height would result in reduced business efficiency, in substantial declines in land values in the central districts not fully compensated elsewhere, and in a serious readjustment of the whole tax structure and of the city economy generally.

4. Not only does the skyscraper make possible the maximum economic return from the private owner's standpoint but it does so primarily because it performs efficiently an important economic function from the public viewpoint. Measured by its contribution to public welfare, it deserves to rank with the telephone and the automobile as one of the great modern American inventions.

5. Despite frequent claims to the contrary the tall building does not in itself throw an increased monetary burden upon the community for the provision of the ordinary civic utilities. Such claims are based on a confusion between the effect of increased height and the effect of growth in population and business activity.

6. While sunlight and fresh air may not be ideally protected in a few of the lower floors of all high buildings and on the street surfaces of all high building districts, conditions in the upper floors of modern skyscrapers are far superior to those found in low buildings. Moreover, the modern setback regulations, as applied for instance in New York City, offer a practicable method of effecting a reasonable compromise between real estate values and the community's current conceptions of desirable light and air protection.

7. Public safety is not endangered by the tall building built to the standards of a modern building code. The record of the modern skyscraper in regard to hazard from fire and natural catastrophe has been quite exceptional. In particular, it has been demonstrated that fireproof buildings can be built and, while the possibility of fire from combustible contents always exists, the improvement in fire-fighting equipment and

technique as reflected in an up-to-date building and fire code has been so great that the possibility of serious danger to the structure or its tenants has been almost eliminated.

8. The effect of the tall office building upon traffic congestion has, to say the least, been seriously exaggerated. It is not *the* cause nor even the *major* cause of such congestion. Compared with some other types of buildings and with the automobile it is a minor offender. It does concentrate many people upon a small area and to that extent may lead to rapid transit and pedestrian congestion in certain limited areas. Compared with vehicular congestion, these problems are relatively easy to solve. To some extent it tends actually to relieve traffic congestion because it facilitates regional specialization, makes possible the specialized and the multi-purpose building and results in the substitution of vertical elevator traffic for a large volume of horizontal street traffic. In any case, the traffic problem can and should be solved by the application of more direct and logical remedies than arbitrary limitations upon building height, which are likely to have serious, unforeseen consequences.

Evils Can
Be Remedied

In short, the authors approached the skyscraper problem from the strictly economic point of view. When an exhaustive investigation seemed to demonstrate beyond peradventure that under appropriate conditions the skyscraper was economically sound, a firm basis was laid for the consideration of the remaining arguments which have been advanced against the skyscraper. As a result of such consideration, these arguments soon revealed themselves as the normal type of criticism against evils, fancied or real, which are bound to accompany the introduction and development of any great new economic idea. For such is the skyscraper,—a new and powerful economic idea or force with which is being recreated the framework of the cities which our grandfathers fashioned for an age of horse-drawn vehicles and of small things in population and in commerce. If, therefore, the skyscraper

results in "blighted districts", we are inclined to accept these deteriorated neighborhoods as part of the cost of progress, except to the extent that far-sighted and intelligent planning may reduce their importance. If we find that unregulated development of the skyscraper results in danger to public health through abnormal restrictions of light and air, we are willing to recommend such reasonable regulations as will insure that quota of sunlight and air which the community considers necessary and is willing to pay for. If lack of regulation would be likely to result in danger to public safety from fire or natural catastrophe, we insist on such safeguards as will reduce these hazards to a minimum. If the development of the skyscraper is accompanied by serious traffic congestion, we wish first of all to disentangle by thorough research the effects of mere growth in the city's population and business from the effects of increased building height and then to apply such logical remedies to increase transportation facilities as careful investigation shows to be desirable but always without blocking progress in a given direction.

We have no quarrel with the idealist or with the visionary but only with the idealist whose ideas are half-baked and with the visionary whose vision is too limited. We have no quarrel with city-planning or with zoning but only with those self-appointed architects of city structure who do not realize the tremendous power and complexity of the forces with which they are dealing. On the contrary, we believe in the desirability of more citizens framing visions and dreaming dreams of greater and better cities of the future in which health and happiness as well as economic efficiency will play an important part. We firmly believe, moreover, in the necessity of city-planning and zoning to give intelligent direction to city growth, and only insist that it be far-sighted, intelligent, based on sound research, inspired by constructive imagination. Our quarrel is essentially with half-baked theories, with inadequate analysis, with the romanticism that

Flexible Regulation
Not Arbitrary
Restriction
Required

throws a glamour over the past, and with the bureaucratic mind—from all of which come those proposals to place *arbitrary, flat-level restrictions* upon building height which would sacrifice the public benefit latent in a great new economic device and lead ultimately to serious unforeseen consequences. In other words, our conviction is that the skyscraper has tremendous possibilities for public good, that these possibilities should be allowed to develop into actualities, and that community control should content itself with *flexible regulation* designed to minimize the evils that might accompany unregulated development.

The Skyscraper,
Symbol of
American
Civilization

On the whole, it has been this latter type of policy under which the skyscraper has developed in most American cities. The result has been in most cases a natural evolution, with the tall building gradually forging for itself a more important place in the scheme of urban life, creating certain new problems but gradually finding solutions for them, and increasing constantly in efficiency, in size and height, in beauty and grandeur. Utilizing the only new architectural principle evolved since the days of the Romans, it was the necessary result of American conditions. With each passing decade it has become more and more a part of the fibre of American civilization, contributing to its efficiency, reflecting its economic conditions, typifying its passion for achievement, furnishing it with an outlet for creative genius in the aesthetic field. Forty years ago a rather timid experiment in a new method and a new material, it produced a structure which, however efficient, was ugly, new-fangled, somewhat illogical. In a single life-span, American architects and builders have attained such a mastery over the new method and the new material and such a freedom from the influence of Old World models that today our skyscraper architecture is universally acclaimed as the major contribution of this country in any field of creative art. Not all skyscrapers are beautiful but more and more instances occur where beauty has been added to utility. The skylines of our cities make a deep impression

upon the European visitor because of their beauty and grandeur.⁽¹⁾ The skyscrapers which make up those skylines are the pride of our own citizens, because they are so typically American, because they are the biggest, the tallest and the most compelling the world has ever seen, because they symbolize more strikingly than anything else the tremendous achievement of this continent in large scale mechanical production. If the thesis of this Report be correct, that national pride has a large measure of justification.

A valuable table listing tall buildings and giving information regarding their names, locations, size of plots, heights, cubic contents and rentable areas is published by the American Institute of Steel Construction in their "Facts About the Structural Steel Industry".

- (1) "New York at certain hours and from certain points of vantage is a vision of overpowering beauty American architecture is one of the most vital poetic forces the world has ever known,"—Alfred Noyes in London Sunday Times, January 9, 1926.

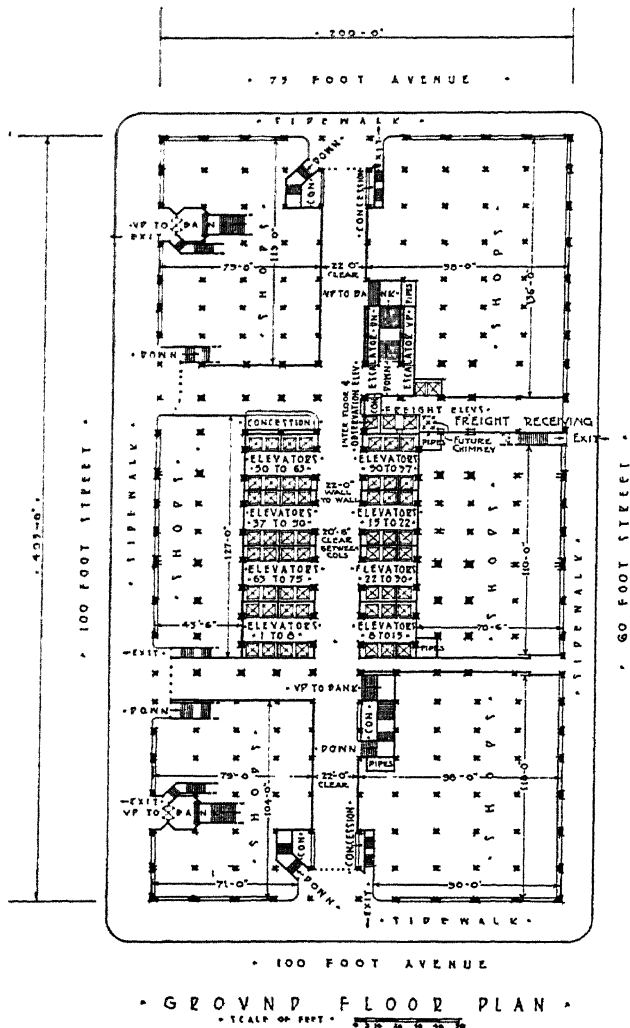
"A subject fit for the brush of a Turner."—Sir John Lavery, N. Y. Herald Tribune, January 2, 1927.

"Actually, it (the skyscraper) is the one new thing in the architectural world, and it typifies America the world over. I think it safe to say that if the United States ended tomorrow the skyscraper would probably be looked upon as that country's greatest contribution to world development Seldom has architecture so accurately portrayed the characteristics of a nation as does the skyscraper."—Alfred C. Bossom, Fellow of Royal Institute of British Architects, N. Y. Herald Tribune, July 22, 1928.

"Not all of the skyscrapers are great works of art. But it is well to remember that the Greeks, at their best, did not produce a masterpiece every time. The artistically trained men of Europe concede that America in her skyscrapers today leads the world."—Alfred C. Bossom, N. Y. Times, November 27, 1928.

"Where the Venetian drove stakes into his sandbanks to overcome nature, the American has pegged his city to the sky. No sight can be more exhilarating and beautiful than this triumph of man, who, for lack of space, has scrapped all the traditions Anything is possible of realization in America today; that is why old New York is, I think, the most beautiful city."—C. R. W. Nevins in London Daily Chronicle, quoted in New York Times, December 8, 1929.

APPENDIX I.

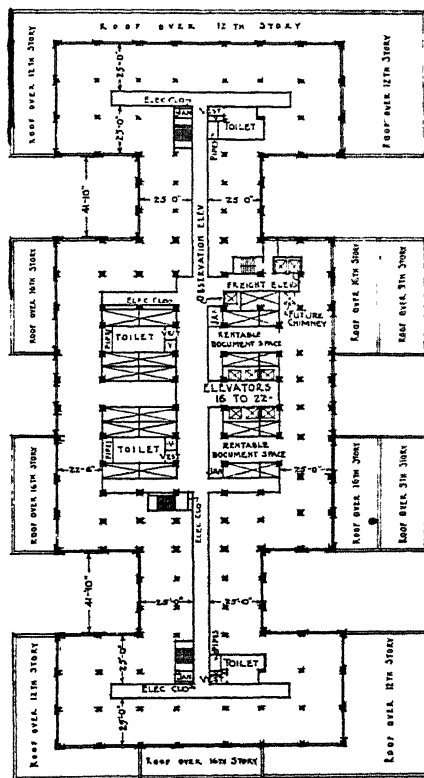


STUDY OF ECONOMIC HEIGHT FOR OFFICE BUILDINGS

7 STORY SCHEME

J. L. KINGSTON
ARCHITECT

100 FOOT STALLY -



60 FOOT STREFF

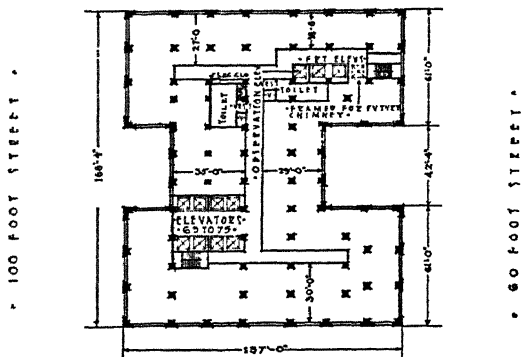
- TYPICAL OFFICE FLOOR (LOWER PORTION)
- FOR ADDITIONAL OFFSETS SEE ISOMETRIC -
- SCALE OF FEET -

STUDY OF ECONOMIC HEIGHT FOR OFFICE BUILDINGS

J L KINGSTON
ARCHITECT

73 STORY SCHEME -

• 75 FOOT STREET •



• 100 FOOT STREET •

• TYPICAL OFFICE FLOOR (TONER) •

• FOR OFFSETS SEE ISOMETRIC
• SCALE OF PART •

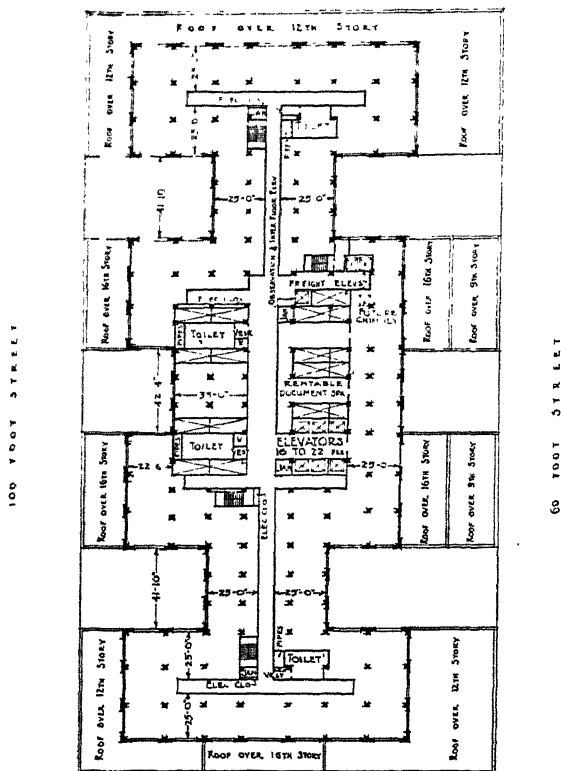
• SCALE OF FIFTY •

STUDY OF ECONOMIC HEIGHT FOR OFFICE BUILDINGS *

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ARCHITECT

77 STORY SCHEME ~

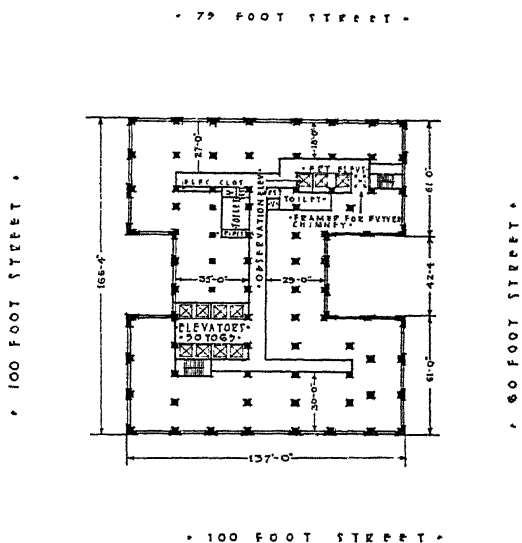
75 FOOT AVENUE



100 FOOT AVENUE

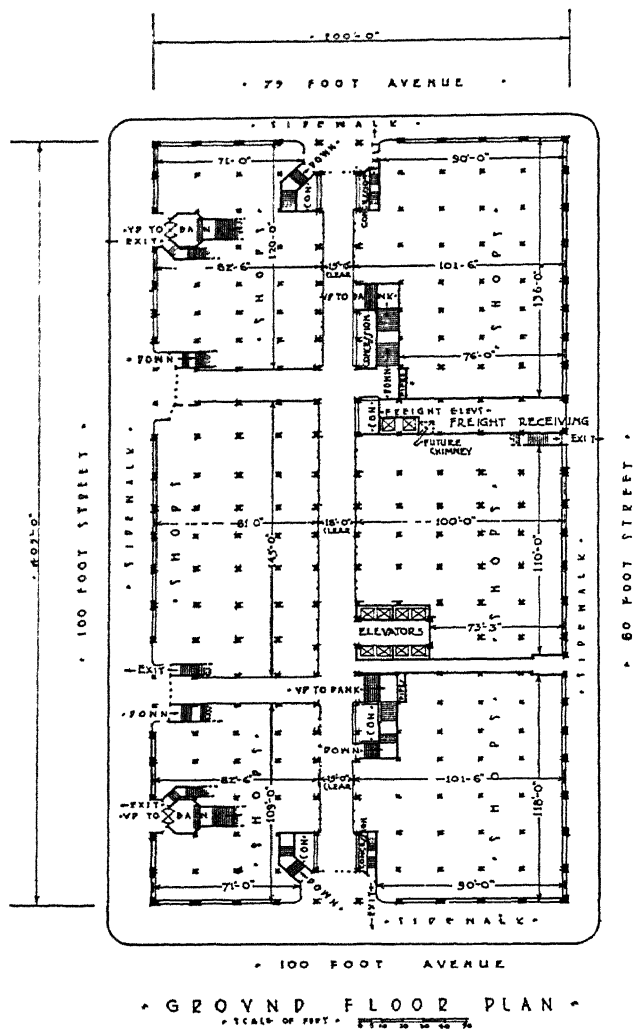
- TYPICAL OFFICE FLOOR AT INTERMEDIATE OFFSETS -
FOR ADDITIONAL OFFSETS SEE ISOMETRIC
SCALE OF FEET 0 10 20 30 40 50

- STUDY OF ECONOMIC HEIGHT FOR OFFICE BUILDINGS -
J. L. KINGSTON
ARCHITECT
- 63 STORY SCHEME -



• TYPICAL OFFICE FLOOR (TOWER) •
 • FOR OFFICE USE ISOMETRIC •
 • SCALE OF FOOT • 0 10 20 30 40 50

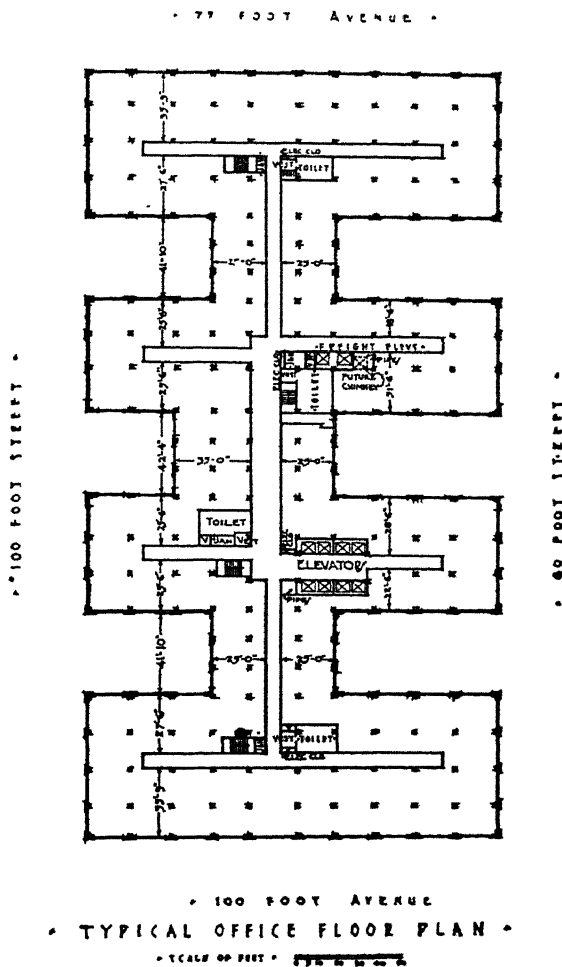
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STUDY OF ECONOMIC HEIGHT FOR OFFICE BUILDINGS

8 STORY SCHEME

J. L. KINGSTON
ARCHITECT



• STUDY OF ECONOMIC HEIGHT FOR OFFICE BUILDINGS •
 J.L. KINGSTON
 ARCHITECT
 8 STORY SCHEME •

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